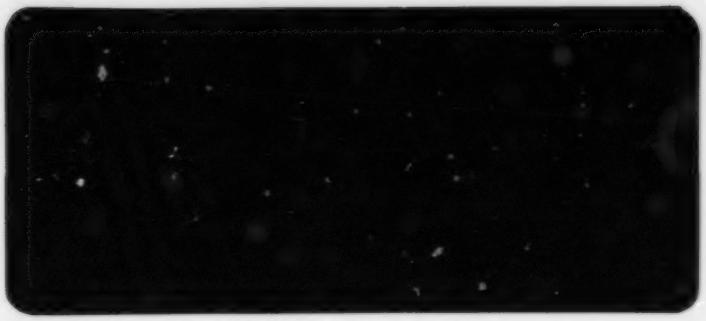

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91-02742/

COAL GEOLOGY GEOSCIENCE INFORMATION SYSTEM PILOT STUDY

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Open File Report 1989-03A
Alberta Geological Survey
Alberta Research Council

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FOREWORD

During the last decade the computerization of geological data and new computer applications have revolutionalized geological research. Substantial advances in spacial data storage, display and analysis have been realized in the municipal and non-renewable resource sectors, particularly in forestry. The new technology has been termed Geographic Information Systems (GIS). Worldwide, governmental organizations responsible for base mapping have changed from traditional methods to digital mapping techniques. The geological community, during the last five years, has joined the revolution and is only now discovering the potential and limitations of GIS technology. This pilot study was designed to explore GIS capabilities and limitations for geological research while producing a useful product that could be built upon.

Discussions with our clients in industry, Alberta Energy and Forestry Lands and Wildlife indicated that available coal geology information is not being used extensively for Alberta coal development planning, resource planning, or in the administration of mineral agreements. Resource management in Alberta is mainly focused on surface contraints, particularly natural surface features, policies and plans. The Coal GSIS demc demonstrates how geological and non-geological data can be queried, analysed and displayed by operators with or without computer and/or geological expertise.

ACKNOWLEDGMENTS

The Alberta Office of Coal Research and Technology (AOCRT), Alberta Energy (AE), and the Alberta Research Council (ARC) provided joint funding for all phases of this project. Heather Watson did most of the preliminary demo design, data input and provided training and expertise that was critical in the early stage of the project. Harry Lewis and David Wiley of the Energy Resources Conservation Board (ERCB) provided permit and lease data in digital format. TransAlta Utilities Corporation (TAU) provided maps and data on which many of the demo layers are based. Dennis Nikols and Greg Mandryk provided many useful comments on the design of the demo. Greg Mandryk also formatted data and contributed a major part of the section on future plans. Diane Goulet digitized some of the maps. Dale Fietz and Norman Chidambaram provided the file size statistics. Maureen FitzGerald and Kathie Skogg helped prepare the final manuscript and the Graphics staff at the Alberta Research Council prepared a number of the black and white line drawings.

The manuscript was critically reviewed and constructive comments were provided by Dennis Nikols, Greg Mandryk and Dale Fietz. Peter McCabe (U.S. Geological Survey) helped with the initial project concept and design.

EXECUTIVE SUMMARY

As part of a GeoScience Information System (GSIS) pilot project a demo for coal-related information was developed at the Alberta Geological Survey. It should be stressed that the pilot project demo is the primary product of this project, not this compilation. This report is intended to provide an introduction to the pilot demo and provide support documentation for the project and the demo.

Management of information related to coal resources involves complex operations on tabular data bases and mapping systems. Traditionally, Data Base Management Systems (DBMS) and Mapping Systems were two distinct software packages. Tasks often involved complex transfers of files between systems. Geographic Information Systems (GIS) allow for functional graphics and analysis integration within one package and using one data base platform.

The system created during this study operates under the shell of pcARC/INFO. A menu system was created within the shell to allow for standard queries by geologists having no special training in computing systems. In addition to the above capabilities, the Coal Section's GSIS will provide a graphic query window for the Alberta Geological Survey's (AGS) Coal Data Base created in the INGRES relational database system residing on a VAX 780.

The GSIS system is designed on four levels of detail (figures 1 and 2):

Level One - 1:1000 000 maps include general coal information for the province of Alberta.

Level Two - 1:250 000 scale maps include the above noted information plus selected information on coal disposition, mine permits and on oil and gas well locations.

Level Three - in addition to information available on Level Two, selected subareas identify names of oil wells and mine permits; as well the 400 m development buffer zones have been identified for the oil wells.

Level Four - 1:5000 mine or township scale maps include detailed information concerning coal seam thickness (detailed contour maps), coal quality, overburden and stratigraphy for the areas.

On all levels, selected information may be linked (related) to the AGS's Coal Data Base by an index key item. The system has the capability of producing hard copy output in the form of high-quality color or black and white maps and/or reports from any combination of available data. The system will also produce new maps from existing information, and allows for the interactive composition of custom thematic maps to display geological information.

The demo illustrates how the GIS technology can serve as an exploration, research and information platform for the 1990's.

INTRODUCTION

OBJECTIVES

The Coal GeoScience Information System (GSIS) pilot project demo was developed to explore and demonstrate the capabilities and limitations of Geographic Information System (GIS) technology for support of coal geology research and coal resource management activities.

METHODS

DESIGN PHILOSOPHY

The design philosophy was based on developing a demo that demonstrated GIS capabilities while showing how coal (geological and non-geological) data could be stored, retrieved and analyzed in novel ways. In addition, the demo had to be easy to use, flexible and be of use toward developing an operational system.

Basic considerations included:

- the system must be capable of being expanded to a province-wide system;
- the area of focus for the pilot demo would centre on Townships 50 to 53, Ranges 3 to 5 West of the 5th. Meridian; the defined area contains major operating coal mines;
- the demo system must be interactive to both database and graphics;
- the demo interface must be simple, relatively transparent and appear seamless to the user;
- a large number of overlays (10 to 20) must be possible;
- the exchange formats with other mapping and graphics software such as CPS Radian, SURFACE II, INTERGRAPH and AUTOCAD must be possible;
- the final hardcopy and screen output must be, or approach, CAD

quality;
- the demo system hardware must be transportable and have a large file storage capacity.

The GSIS system was designed on four levels of detail (figures 1 and 2):

Level One - 1:1 000 000 scale maps include general coal information for the province of Alberta.

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Level Three - in addition to information available on Level Two, selected subareas identify names of oil wells and mine permits; as well the 400 m development buffer zones have been identified for the oil wells.

Level Four - 1:5000 mine or township scale maps include detailed information concerning coal seam thickness (detailed contour maps), coal quality, overburden and stratigraphy for the mining areas.

On all levels, selected information can be linked (related) to the AGS's Coal Data Base by an index key item.

The demo was designed to illustrate how GIS technology can serve as an exploration, research and information platform for the 1990's.

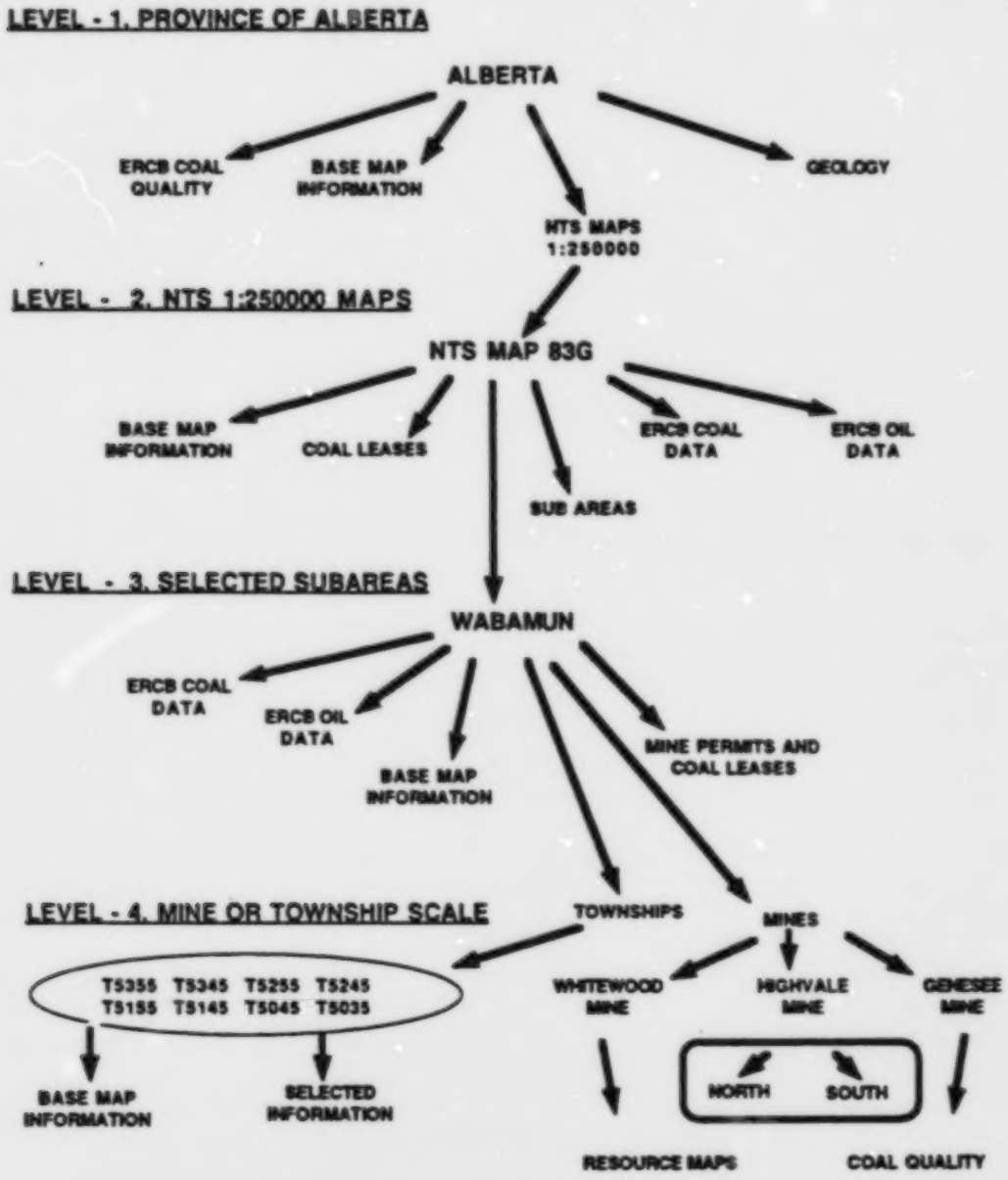


Figure 1. The Coal GSIS demo menu system design.

PROCESSING

Hardware (The Workstation)

The bulk of the project work was carried out on a MS-DOS 386 class microcomputer to establish the computing costs.

Some basic considerations included:

- the final hardcopy and screen output must be, or approach, CAD quality;
- the system must be interactive to both the database and graphics;
- the processing can accommodate both raster and vector;
- the system must be transportable and have large storage capacity.

The chosen hardware allowed for a full examination of the pcARC/INFO software and exceeded the minimum requirements needed to run the software package. The selected COMPAQ 386/20 (Deskpro) micro-computer was configured with a 2Mb. RAM memory, a 80386 20 Mhz. microprocessor, a 5 1/4-inch 1.2Mb. floppy disk drive and a 300Mb. internal hard disk drive, which has an access time of less than 20ms. A 125Mb. internal tape back up which backs-up 5Mb. per minute; a 32 Kbytes high speed Cache memory controller, 1 parallel and 2 serial interface, and a 80387-20 math co-processor completes the computing and storage components of the workstation. The cost of the basic workstation totalled $19,940.00.

Additional hardware comprised the followings components:

- a Hewlett Packard PaintJet printer, costing $1,628.00; the printer can produce high (180 dots per inch) resolution color prints on standard 8.5 x 11 inch paper;
- a Calcomp 9100 digitizing table with a 44" x 60" maximum working space and a 16 button digitizer;
- a Calcomp drawing board, costing $3,500.00, the drawing board can emulate the Calcomp 2000 and has an 18" x 18" active area

and a 16 button digitizer;

- a NEC Multisync Plus monitor, costing $2,495.00; the monitor scans all frequencies between 21.8 kHz and 45 kHz; it has a horizontal resolution of 720 lines with 960 dots per line and has both TTL and Analog signal inputs; the diagonal display is 15" while the viewing area is 14";
- a Etherlink Plus adapter, costing $1,165.00, the adapter allows the Compaq to communicate with the host VAX/VMS computer more efficiently.

The total cost of the hardware was $28,728.00 (table 1.).

Table 1. Hardware costs.

Components	Cost ($)
Compaq Deskpro. 386/20	19,940.00
HP Paintjet Printer	1,628.00
Digitizing Table (Calcomp 9100)	on loan
NEC Multisync Plus monitor	2,495.00
Calcomp Drawing Board	3,500.00
EtherLink Plus Adapter	1,165.00
Total:	$28,728.00

Software

The software selected for the Coal GSIS coal pilot project demo was a package called pcARC/INFO which was obtained from Environmental Systems Research Institute (ESRI). One of the advantages of this software was its capability to download and upload data sets from/for other mini-based ARC/INFO systems in place at other Alberta government departments. The pcARC/INFO based system was purchased before ARC/INFO became available on the Alberta Research Council's mini-computers. In hindsight, pcARC/INFO would still have been purchased even if the mini system had been available. By using pcARC/INFO it was possible to maintain control of the system for experimentation and establish computing costs.

The basic pcARC/INFO software module is called the 'ARC/INFO STARTER KIT'. It provides basic functions such as digitizing, coordinate transformation and the reading of ASCII input files into the GIS system. The starter module costs $3,600.00. There are six pcARC/INFO options available, each of which cost $1,800.00; a description of their functions follows:

1. pcARCedit provides the capability to edit any digital coverages in the system.
2. pcARCplot provides the capability to display maps on color graphics monitors and create high quality cartographic plots. pcARCplot also provides interactive query functions that allows users to display specific features.
3. PC INFO allows users to input and relate spatial data to the graphic coverages; PC INFO permits users to link databases to their graphic expression and further provides for import and export of databases in various formats.
4. pcGRIDCONVERSION provides the ability to exchange data between pcARC/INFO coverages and grid cell formats.
5. pcARC SIF (Standard Interchange Format) allows the file transfer between the pcARC/INFO and Intergraph; SIF is a command lanaguage written and used by Intergraph for ASCII transfer of design files.
6. pcOVERLAY provides advanced capabilities for manipulating and analyzing geographic information including polygon overlay, line- and point-in-polygon overlay, buffer creation, dissolve functionality and more - all based on a geo-relational topological data structure.

The total cost for the complete pcARC/INFO software used in the project was $14,400.00 (table 2).

Table 2. pcARC/INFO software cost.

Options	Cost ($)
pcARC/INFO Starter Kit	3,600.00
pcARCedit	1,800.00
pcARCplot	1,800.00
PC INFO	1,800.00
pcARC SIF	1,800.00
pcGRIDCONVERSION	1,800.00
pcOVERLAY	1,800.00
Total:	$14,400.00

The total cost of the hardware and software used in the pilot demo was $43,128.00.

TECHNIQUES

Introduction to pcARC/INFO

The following section documents the usage of the pcARC/INFO software and provides shortcuts to using the system. It is not intended to replace the ESRI manuals but rather, to be used with the manuals to determine how the pilot demo was constructed. It is not designed as a "cook book" for those unfamiliar with ARC/INFO but, as "shorthand" for the novice operator.

Terminology:

Point	- a single x, y coordinate pair that defines the location of a map feature.
Line	- a set of ordered points which are connected and represent a map feature.
Area	- a closed figure bounded by one or a series of line features that enclose a homogeneous area.
Coverage	- a digital version of a map.
Polygon Coverage	- coverage composed of polygon (area) features.
Line Coverage	- coverage composed of linear features.

Point Coverage	- coverage composed of point features.
Network Coverage	- coverage composed of both areas and line features.
Link Coverage	- coverage composed of both point and line features.
Arc	- line feature, the border of a polygon, or both in a coverage.
Polygon	- area feature defined by the set of an area which comprise it's border and a label point within the polygon which is used to assign a USER-ID.
Label Point	- point feature in a point coverage and polygon label point in a polygon coverage.

Each coverage has two components:

1. graphics
2. info files

- the graphics component allows you to draw the coverage to the screen (or send it to the plotter).
- the info files store attribute data for the features in the coverage.

(coverage).TIC	- control points used for future coordinate transformation;
(coverage).BND	- defines boundary of coverage (all features must fall within these limits);
(coverage).PAT	- Point Attribute Table or Polygon Attribute Table (depending on the type of coverage);
(coverage).AAT	- Arc Attribute Table - stores attributes of linear (arc) features;
(coverage).GAT	- Graphics Attribute Table - stores detailed information about feature graphics.

Procedures:

1. Digitizing a map.

Possibly the single most important aspect of digitizing is determining a realistic degree of detail. In many cases it would either be impossible to digitize all of the features on a map or it would take an inordinate amount of time to do so. Prior to digitizing, it is advisable to decide exactly which features on the map that you wish to represent (those that best represent the trends or distribution of features on the map) and the procedure you might use to digitize the chosen features. By doing this you are basically charting a 'plan of attack'.

As a general rule, always digitize a line or a polygon

counterclockwise. If the contour lines of the map are too close together, use mapex * to zoom in on an area before digitizing in order to make sure that the contour lines that you digitize do not cross each other. Make sure that each line with "the same value" but in two different mapex * areas joins because it is a lot easier to clean the unwanted danglers than to join two unjoined lines. Use Vertex (1) to construct the line and node (2) to start a line and to end a line.

Getting Started.

1. Turn on machine (conditioner, drive, monitor and digitizer).
2. When system is "up" go to work area, i.e., CD Coal Work or whatever.
3. Place Info disk in drive.
4. Access Arc/Info by typing 'ARC' [enter].
5. To begin digitizing a coverage type 'ADS (coverage name)' [enter]
   - if this is a new coverage try to choose a name that is representative of that coverage, i.e. 1503 was the name chosen for the coverage representing the 150pach map of seam 3.
6. Register TICS.
   - type '01A' and any number on the spot you select for your tic location
   - type '02A' and any number - at 2nd tic location
   - type '03A' and any number - at 3rd tic location
   - type '04A' and any number - at 4th tic location
   - type '0A' to stop entering tics

   - NB - must have a minimun of 4 tics
     - use section corners as tic locations
     - circle them in pencil on the map

If using a pre-existing coverage, you must digitize TICs that were used in the initial digitizing of the coverage (they will be circled in pencil on the map and should always be a section corner).

RMS error must be less than 0.003; if higher then the locations must be re-digitized.

Once TICs are entered and the RMS is satisfactory the main menu should appear.

7. Set edit distance (search tolerance) - press '8' (options menu), press '3', press '1', then enter an edit distance through keyboard (the distance is usually 0.05).

8. Set snap distance (distance to which points on arcs will snap) from main menu:
   - press '5', press '1'
   - enter distance usually (0.001) using keyboard.

   Set weed tolerance distance in options menu to be the same as the snap distance.
   - press '5', press '1'
   - enter distance (0.001) using keyboard.
   - press '9' to return to main menu.

*if you are editing a pre-existing coverage set the snap (SD) and edit distances (ED) once you have windowed (zoomed in on) the area which you want to edit.
*if you cannot select arcs the machine continues to beep; if arcs won't snap the edit and snap distances are usually too small; reset the edit and snap distances.

9. Digitizing - Arc Coverage
   - at the main menu press '1', this brings up a sub-menu for the addition of arc features.

      (i) set auto increment to '0' - enter '6'0'A' with digitizer
      (ii) set user - ID to whatever value you want by pressing '3' and
      entering the value followed by the letter 'A'

   At this point you should digitize all arcs that you want to have that - ID.

   e.g. in digitizing a contour map, all lines representing the 150' foot-value contour would have the same ID eg 150.

   Try to assign the ID by its contour number because it is unique and representative.

2. 'CLEAN'ing the coverage.
   - this creates nodes at intersections
   - creates attribute table (PAT)
   - always clean the coverage to a different name thus preserving the original data
   - use a relatively small dangle and a very small fuzzy tolerance (unless you are very aware of what cleaning might do to the coverage) e.g. [ARC] clean cov1 cov2 0.05 0 [enter]

command	input coverage	output coverage	dangle length	fuzzy tolerance

3. 'BUILD'ing the coverage with the line option.
   e.g. [ARC] Build cov2 line [enter]
   - creates an ARC attribute table (AAT) for the arcs in the coverage

4. 'TRANSFORM'ing the coverage.
   - enables you to change the coordinate space of a coverage, i.e. from inches (as digitized) to UTM coordinate
      i) [ARC] copycov cov2 cov3 [enter] - this makes a copy of cov2 and calls it cov3

      ii) Tape INFO or TABLES - (username in TABLES or INFO is ARC)
      - must have an INFO disk in A: drive to invoke INFO

      iii) Select cov3.tic [enter] - the file you wish to work on
      Reselect $recno = 0 [enter]

Calc XTIC = (corresponding UTM easting value) [enter]
Calc YTIC = (corresponding UTM northing value) [enter]
Nsel [enter]
Reselect $recno = 2 [enter]
Calc XTIC = (corresponding UTM easting value) [enter]
Calc YTIC = (corresponding UTM northing value) [enter]
Nsel [enter]
*repeat for $recno=3 and $recno=4 and so on.

Once all the TIC values have been calculated,
ASEL - selects all records in the table
LIST - lists the information
Ensure the values are correct.
Type Q STOP - exit INFO or TABLES

iv) [ARC] TRANSFORM cov2 cov3 [enter]

5. Incorporating a Boundary * this is not needed in all cases.
[ARC]:ARCEDIT [enter] (* only if the coverage needs the boundary for editing)
: display4 [enter] - sets display to monitor
: editc cov3 [enter] - edit coverage is cov3
: drawenv ARC [enter] - these features that you wish to have appear on the screen
: draw - [enter] draws the features in the Drawenvironment
: editf ARC [enter] - sets the features that you wish to alter to Arcs
: get (coverage name that contains the boundary) [enter]
- will bring to cov3 all of the current edit feature elements (ARCS) in the boundary coverage
: save [enter] - save the changes that you have made to cov3
: Q [enter] - exits ARCEDIT and returns to ARC

6. [ARC] Clean cov3 cov4 0.05 0 [enter]

7. [ARC]Nodeerr cov4 dangles [enter] - lists all of the dangles in cov4
In order to correct these dangles:

- [ARC] arcedit [enter]
- [ARC] display 4 [enter]
- [ARC] editc cov4 [enter]
- [ARC] drawer ARC NODE DANGLE [enter]
- [ARC] draw [enter] - those features in the Drawenvironment should appear in
- ARCs and dangling nodes - dangles will have red boxes around them
- [ARC] editf ARC [enter]
- [ARC] sel many [enter] , selection menu will come up, place cursor on the dangle that you want to select and enter 1; the dangle will flash; repeat the selection until all dangles are chosen; enter 9 to quit
- [ARC] setdrawsymbol 2 (red) [enter]
- [ARC] drawsel [enter] (all the selected dangles should turn red)
- [ARC] delete - to delete all dangles

- [ARC] save [enter]
- [ARC] quit [enter]

NOTES:

<u>To set edit distance</u>

[ARC] ED [enter] - cursor will appear
- set using arrow key
- point registration by setting any key or spacebar

<u>To set snap distance</u>

[ARC] SD [enter]
- set in a similar fashion as edit distance (as above)

<u>To zoom</u>

[ARC] Mapex* [enter]
- cursor will appear - use to set lower left (ll) and upper right (ur) corners of the rea (box) that you wish to enlarge
- use arrow key to position cursor and any key to register points

[ARC] DRAW [enter]
- will show only the defined area in an enlarged state

*this procedure can be done a number of times

<u>To get out of a zoom</u> (to return to full screen view)

[ARC] Mapex cov 4 [enter] coverage name
[ARC] Draw [enter]

<u>Selection of features</u>

*make sure you have a reasonable edit distance
*make sure that you have the correct edit feature

[ARC] select
- allows the selection of a single feature

[ARC] select all
- select all of the current edit feature elements

[ARC] select many
- allows the selection of one or more features (if you select the wrong feature first, this command allow you to continue selecting features in the area - using the 'NEXT' option - until you select the correct feature)

<u>To draw selected set in another colour</u>

[ARC] setdrawsymbol (colour)

<u>Line colour symbols</u>

1. white(black)	6. light blue	11. vibrant green
2. red	7. magenta	12. vibrant blue
3. green	8. dark grey	13. olive
4. blue	9. light grey	14. light blue (vibrant)
5. yellow	10. pink	15. violet

[ARC]Drawsel - will draw the currently selected set of features

using the currently selected symbols

To remove features from the selected set

Unselect - enable the removal of one feature from the currently selected set
Unselect many - enables the removal of one or more features from the currently selected set

To select the currently unselected set

[ARC]Nsel - selects the currently unselected features e.g. there are 70 features in a coverage; using select many, you select 20 features (they are the currently selected set); if you issue the Nsel command at this point, the previously unselected set (consisting of 50 arcs) becomes the selected set and the previously selected set becomes the unselected set

To add features to the selected set

[ARC] Asel - stands for all select
- will select all elements of the current edit features in the coverage

[ARC] Asel one - will add one element to the currently selected set

[ARC] Asel many - allows the addition of one or more elements to the selected set

8. [ARC] Build cov4 - builds coverage with 'poly' default option
Build cov4 line - builds coverage with 'line' option
Build cov4 point - builds coverage with 'point' option

9. Check to make sure that there are no node errors
i.e. [ARC] nodeerr cor4 dangles [enter]
- when all nodeerrors (dangles) have been removed, proceed to step 10

10. [ARC] additem cov4.AAT cov4.AAT level 4 5 B

command	input cor	output cor	item name	input width	output width	item type

[ARC] additem cov4.AAT cov4.AAT value 8 9 N 2 [enter]
↑
# of decimal places

- by issuing these commands, you are adding two new items to the arc attribute table (AAT) of the cov4

11. [ARC] Build cov4 line [enter] - this includes the added items in the info files (topology) of cov4)

12. Update/calc values for .AAT
(cov4.AAT)

cov4 #	Cov4-ID	level	value
1	325		
2	300		

this table represents the last 4 items in the cov4.AAT info file after step 11

3	450
4	475
5	350
6	500
7	500
8	425
9	375

in order that you might fill in level and value information, it is perhaps easiest to create a chart as below.

This table was built by determining the minimum and maximum values of the arcs that were digitized and assigning 'levels' to them.

In order to enter this information into the INFO table you can, in this case, enter the following command
[Command] Resel cov4-ID = 300 [enter]

Level	Value
1	3.00
2	3.25
3	3.50
4	3.75
5	4.0
6	4.25
7	4.50
8	4.75
9	5.0

[Command] calc value = cov4-ID/100 [enter]
[Command] Nsel [enter]
[Command] list - you should see the value column has been fit in and has the correct map values - i.e. the decimals are in the correct place

In order to determine 'levels' for the data you do the following:

[Command] Resel value = 3.0 [enter] - will reselect all arcs with values = 3.0
[Command] calc level = 1 [enter]
[Command] nsel [enter]
[Command] resel value = 3.25 [enter]
[Command] calc level = 2 [enter]
[Command] nsel
- repeat for all values and levels

At this stage, all records should have levels and values.

<u>To change ARC-ID's</u> (still in the INFO mode)

[Command] Sel cov4.AAT (or Asel the remaining arcs in the cov4) [enter]
[Command] calc cov4-ID = cov4-ID +100 [enter]
[Command] calc cov4-ED = cov4 # [enter]
[Command] Q stop [enter]
- your INFO tables should now be completed (for as far as we have gone)

13. In order for ARC/INFO to realize that you have changed ARC-IDS in INFO, you must enter the following command:
[ARC] idedit cov4 line [enter]
- if you do not use this command to update, the ARC-ID's of the ARC/INFO becomes confused and does not correct attributes for arcs

14. Now check and make sure that all arcs have the correct values in ARCPLOT [enter]
[ARC] arcplot [enter]

```
[ARC] display 4 [enter]
[ARC] mapex cov4 [enter]
[ARC] resel cov4 line value = 3.0 [enter]
                  (or level=1)
[ARC] linec 2
[ARC] arcs cov4
[ARC] clearsel
```

will draw selected arcs in selected colour (red)

```
[ARC] resel cov4 line value = 3.25
[enter]
[ARC] linec 3
[ARC] arcs cov4
[ARC] clearsel
```

repeat for all the values or levels until all the arcs are checked

15. [ARC] createlabels cov4 - [enter] this places label points in each of the polygons in cov4 at one time
    - label may also be added in ADS or ARCEDIT but the 'createlabels' command may save some time and effort

16. [ARC] addition cov4.pat cov4.PAT class 4 5 B [enter]
    [ARC] addition cov4.pat cov4.PAT cvalue 8 9 C [enter]
    [ARC] addition cov4.pat cov4.PAT vmax 8 9 N 2 [enter]
    - this adds 3 items to the .PAT (Polygon Attribute Table) of the cov4

17. [ARC] build cov4 [enter] - builds cov4 with polygon default option
    - it is necessary to build topology after entering 'create labels' and 'additem' commands

18. Correcting labelerrors
    - go into ARCedit, type drawenv arc label and editf label, and see if each label point corresponds to a polygon on the hardcopy map
    - if a label point appears where there is no polygon on the hardcopy map, a sliver polygon exists in the digitized map - correct this whenever it occurs

19. [ARC] build cov4 [enter] - after correcting the labelerrors
    - this step isn't necessary if there were no labelerrors to correct

20. Update/calc values for the .PAT
    Construct a table as below

Class	Cvalue	Vmax
1	<3.0	3.0
2	<3.25	3.25
3	<3.50	3.50
4	<3.75	3.75
5	<4.0	4.0
6	<4.25	4.25
7	<4.50	4.50
8	<4.75	4.75
9	<5.0	5.0

- this will enable you to clarify the polygon

10 <5.25 5.25

- in order to assign classes to the .PAT, go into
  [ARC]arcedit [enter]
  display 4 [enter]
  editc cov4 [enter]
  drawenv ARC LABEL [enter]
  draw [enter]
  editf label [enter]
- select each label and use the 'calc' command to assign the correct 'class' for the polygon (from the above table in conjunction with the hard copy map)

N.B. Before you start assigning classes to polygons, you should select all labelpoints and calculate their class to =0. By doing this, when you assign classes to label points individually and redraw, you can easily determine which label points don't have a class =0 (i.e. the ones for which you have assigned the correct class). This is achieved by using the setdrawsymbol and drawsel commands.

21. After assigning 'class' as in arcedit - exit and build cov4 line
    enter INFO or TABLES and assign appropriate values to cvalue and vmax
    i.e. sel cov4.pat [enter]
    list - the table should have the 'class' item filled in for all but the first polygon
    resel class = 1 [enter]
    calc vmax = 3.0 [enter]
    move '<3.0' to cvalue [enter]
    nsel [enter]
    resel class = 2 [enter]
    calc vmax = 3.2 [enter]
    move '<3.2' to cvalue [enter]
    etc.

22. Arcplot - check to make sure that all polygons have the value (class) that they should have by comparing it with the hardcopy map.

<u>Map Composite</u>

Arcplot [enter] - Display4 [enter]
1. Pagesize 20 20 - define the actual pagesize [enter]
2. Map [coverage] - a new name for the plot file [enter]
3. Mapex [old coverage] - coverages that will be used for the map composite [enter]
4. Box 0 0 20 20 - draw a box [enter]
5. mbegin - to Section all elements into 1 Section [enter]
6. Mapangle (+ or - n degree) [enter]
7. Arc [old coverage] [enter]
8. Resel [coverage] polys class=1 [enter]) colour all class=1
9. Polygonshades [coverage] 2 [enter]) with red
10. Clearsel [enter] etc.
11. Mend - finish Sectioning [enter]
12. Mfit - to specify the size of the map (may not be necessary) [enter]

13. Mmove - to reposition the map [enter]
14. Mfresh - will draw all elements 1 by 1 [enter]
15. text size 0.2 0.2 [enter]) specify the size of text, decide
16. move x y or move * [enter]) where to put the text and enter
17. text 'anything' [enter]) the actual text

N.B. Msel - to select a map element which will be moved or deleted
Mdelete - to delete a specified or the latest map element

<u>To overlay a second map during the map compositing</u>

1. Mapex [coverage1] [coverage2] [enter]
2. Mapangle -0.5 [enter] - make sure that the new coverage has the same angle as the old coverage
3. Arcs [coverage] [enter]
4. Mfit [enter] - if it is too big

<u>To create a legend</u>

1. Quite from the map compositing
2. NE - enter into the Norton Editor
3. filename.key - use .key as an extention for legend file
4. .42 [enter] - the period (.) tells the computer that the following number is not text. 42 is the symbol number
5. text [enter] - texts for the symbol
6. etc.
7. F3 - E (to exit and save)
   or F3 - Q (to exit and not save)

<u>To plot the legend</u>

1. Arcplot [enter] - display 4 [enter]
2. use the same pagesize as the map which you are adding the legend
3. Map [coverage name] - the name of the map [enter]
4. textsize [width] [height] [enter]
5. keyposition * - lets you specify the position [enter]
6. keybox 0.2 0.2 - most frequently used sizes [enter]
7. keyseparation 0.15 0.15 - most frequently used spaces [enter]
8. keyshade filename.key (to shade the box) [enter]
9. quit [enter]

<u>To plot a completed coverage</u>

1. get into Norton Editor (NE)
2. filename .sml [enter]

<u>For Calcomp plotter</u>

3. display 1039 [enter]
4. filename.plt - create a plot file for the calcomp [enter]
5. pagesize - use the same pagesize as the coverage has [enter]
6. maplimit [enter] - use the same maplimit as the coverage if it has one. Specify only when the coverage has one.
7. plot - [coverage file] - map composite file

8. map [enter]
9. Q [enter]
10. arcplot [enter]
11. &run filename.sml [enter]
12. draw filename.plt - to draw plot on screen [enter]
13. plot (to plot on calcomp) [enter]

For the PaintJet printer

3. display 1 [enter]
4. pagesize - same size as the coverage [enter]
5. maplimit - specify only when the coverage has one [enter]
6. plot [coverage file] - the map composite file [enter]
7. map [enter]
8. quit [enter]
9. arcplot [enter]
10. @filename.sml [enter]

To define and to clean danglers

1. <ARC> clean test2 test 3 0.05 0 [enter]
2. <ARC> nodeerr test3 dangles [enter]
3. <ARC> arcedit [enter]
4. display4 [enter]
5. editc test3 [enter]
6. drawenv arc node dangle [enter]
7. draw [enter]
8. mapex * [enter] - zoom in (only if there are too many dangles in one area)
9. ed (edit distance) use the narrow keys [enter]
10. SD (snap distance) use the narrow keys [enter]
11. setdrawsymbol 1 (black on paper - white on monitor) [enter]
    2 (red) [enter]
    3 (green) [enter]
    4 (blue) [enter]
12. editF arc [enter]
13. selmany [enter]

N.B. if you select a wrong line or dangle, use (2) "next" to correct it.
unsel - to unselect the wrong dangles or lines
14. drawsel - to highlight your selection (dangles)
15. delete - to delete the dangles

To transfer coverages from the mainframe ARC/INFO to the pcARC/INFO

Part 1

1. sign on the mainframe ARC/INFO
2. select coverage to be transferred
3. convert coverage to the interchange file using: export cover [input file] [inter_file] N (no compress) [enter]
4. quit from the ARC node
5. enter into kermit
6. send [inter_file] [enter]

7. enter the name of the received file
8. insert disc into A driver - use this only when your PC doesn't connect to the mainframe
9. get out of kermit and return to DOS
10. copy file to drive A at the Xtalk mode

Part 2

1. insert disc into the PC which has the pcARC/INFO
2. use the import command at the ARC node
   import cover a:/filename output filename [enter]

Transforming ASCII, SDF, 20/20, DIF and SYLK files into INFO files

1. create an empty INFO file using Define at the INFO mode
   define name.dat (see page 4-9 to 3-11 of the PC INFO user's guide)
2. at the INFO node type: (see 5-9 to 5-11 of the INFO exchange)
   (a) select name.DAT (an empty file - template) [enter]
   (b) import 'sample.1' dif [enter]
   (c) list (name.DAT should have new records now) [enter]

Joining polygons with databases imported from different systems

1. at ARC node type

	[in_file]	[join_file]	[out_file]
joinitem	coverage.PAT (or AAT)	name.DAT (above)	coverage.PAT

   (or AAT) [relate_item] [start_item]

N.B. The field width of the relate_item must be the same in both [in_file and [join_file]

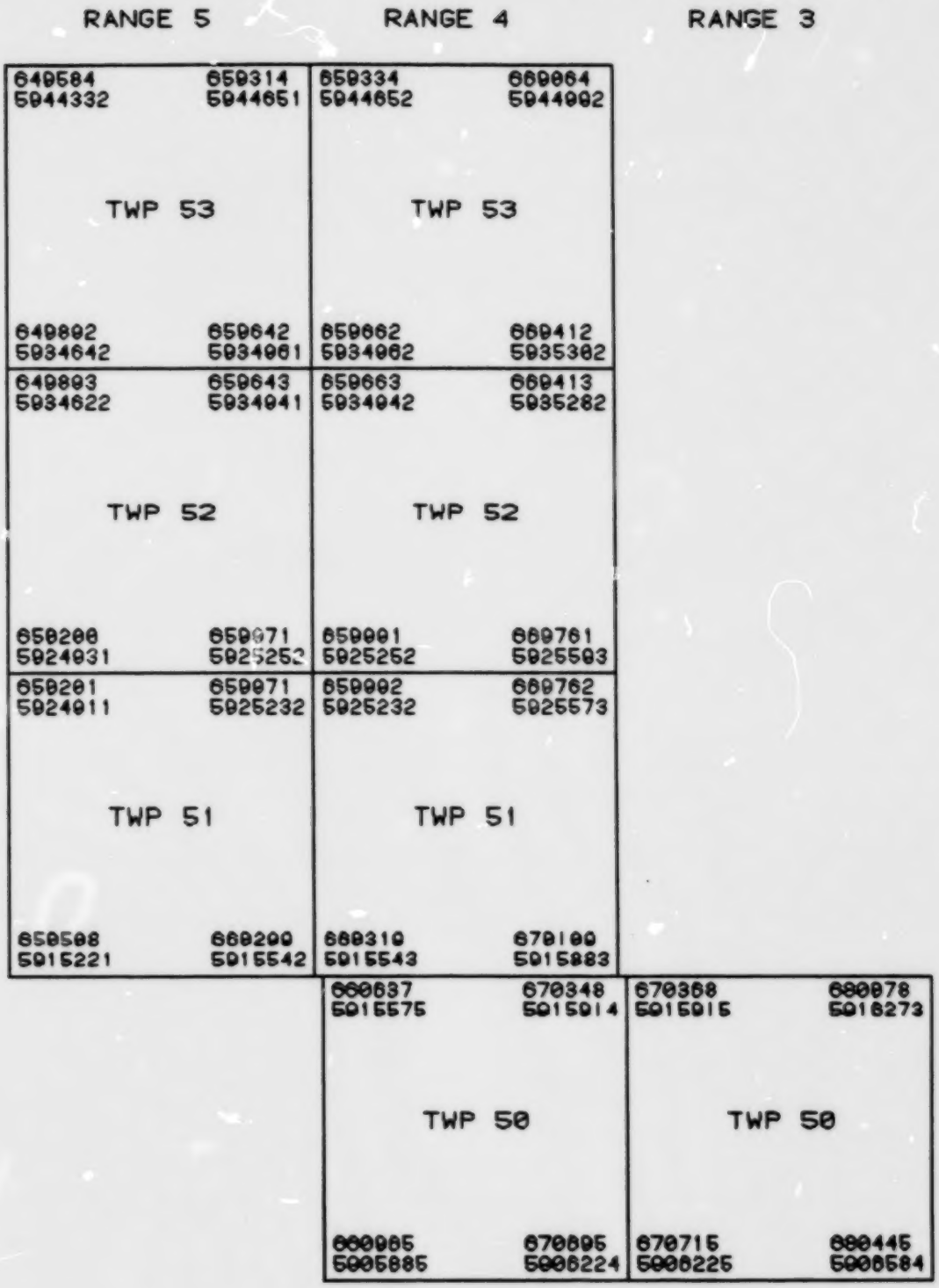
2. enter TABLES to check the PAT or AAT file of the new coverage

Transforming a coverage from 10 TM to 6 TM

1. make sure all tics will fall in the same 6th zone. If they don't, which means they are too far apart, delete the old tics at the <arcedit> and add 4 new ones. If you need reference area/point from another coverage, use <get> filename to bring it in.
2. to delete tics
   <arcedit> editf tics [enter]
   <arcedit> sel all [enter]
   <arcedit> delete [enter]
3. to add new tics
   <arcedit> add [enter]
4. position the cursor at the right place and enter 1
5. repeat step 4 until all 4 or more tics are entered
6. enter 9 to quit adding tics
7. if you have brought in a coverage as reference for your new tics, use command 'removeback' to remove it before quitting the session
8. get into Titan's [coalgis.chao]
   - sign on to Titan and enter coaldata at user's name
   - ask Mandryk or Chao for password
   - set def [.chao] [enter]

- R driver - a program that will convert your 10 TM to lat, long [enter]
- R lat - 6 TM - a program that will convert lat, long to 6 TM [enter]
- type for1.dat to view the result

9. get back to ARC/INFO
10. copycov coverage1 coverage2 [enter]
11. tables ARC [enter]
12. sel coverage2.tic [enter]
13. resel $recno = 1 [enter]
14. calc XTIC = new 6 tm easting [enter]
15. calc XTIC = new 6 tm northing [enter]
16. nsel [enter]
17. repeat step 13 to 16 until all new coordinates are entered [enter]
18. Q stop [enter]
19. transform coverage1 coverage2 [enter]



TOWNSHIP CORNERS IN UTM

Figure 3. Township corners in UTM.

DATA SOURCES

ALBERTA BUREAU OF MAPPING

The digital base map information was obtained from the Alberta Bureau of Survey and Mapping (ABSM). The information is from digitized NTS 1:250 000 and 1:1 000 000 scale maps. The base information is accurate and diverse (tables 3 and 4) providing an excellent base of information. The information forms a major part of the pilot demo (figure 2 and appendix 3). The ability of the GIS software to use reliable locational information such as the Alberta Township Survey (ATS) township corners (figure 3) as templates for new maps was advantageous in developing the demo.

Table 3.

ALBERTA BUREAU OF MAPPING DATA*

Level	Coverage	Feature
1	ATS	Township Boundaries
2	ATS	Unsurveyed Township Boundaries
4	ATS	Section Boundaries
5	SET	Metis Settlement
6	SET	Indian Reserves
8	SET	City Boundaries
15	SET	Provincial Park Boundaries
20	RIV	Double Line River - Perennial River
23	RIV	Single Line River - Perennial River
24	RIV	Perennial River - Tributary
25	RIV	Perennial River - Minor Tributary
26	LAK	Lake Shorelines
27	LAK	Lake Shorelines - Intermittent
30	HWY	Pavec Prime Highway
31	HWY	Pavec Secondary Road
32	HWY	Dual Highway - Paved
33	HWY	Gravel - Secondary Road
35	HWY	Improved Road
36	HWY	Unimproved Road
37	HWY	Truck Trail/Cart Track
39	SET	Railway
40	MDB	Municipal Boundaries (Counties)
50	ATS	Map Boundaries
51	ATS	Marks indicating 50,000 NTS Units

***Note: Levels were received from ABSM without documentation; features were derived from NTS mapsheets and may be in error.**

Table 4.

ABSM COVERAGES

ATS Coverage

Level	# of Records	Feature
1	1939	Township Boundaries
2	30	Unsurveyed Township Boundaries
4	8915	Section Boundaries
50	620	Map Boundaries
51	32	Marks indicating every 50,000 NTS units on easting & northing - i.e. 600000E, 650000E 5900000MN. 5950000MN
		MDB Coverage
40	164	Municipal Boundaries (Counties)
		SET Coverage
5	27	Lac Ste. Anne Settlement - HBC Reserve (Metis Settlement?)
6	49	Indian Reserves
8	49	City Boundaries (?)
15	59	Provincial Park
39	249	Railway
		HWY Coverage
30	384	Road - all-weather, hard surface, 2 lanes Paved, Prime Highway
31	3	Paved Secondary Road
32	10	Dual Highway - Paved
33	115	Gravel, Prime Highway
34	311	Gravel, Secondary Road
35	2591	Improved Road
36	1858	Unimproved Road
37	869	Truck Trail/Cart Track
		RIV Coverage
20	180	Double Line River - Perennial River
23	5	Perennial River - Single Line River
24	1391	Perennial River - Tributaries
25	1115	Perennial Minor Tributaries
		LAK Coverage
26	632	Lake Shorelines
27	132	Lake Shorelines - Intermittent

Conversion of ABSM Supplied SIF/ASCII to Arc Format (UTM Co-ordinates)

```
1.  SIFARC Conversion
        SIFARC (Filename)(Output Coverage) 1006720 Line
2.  Build (coverage) line
3.  Copycov (coverage) (coverage)1
4.  Info
        Select Cov1.T1C
        Calc XTIC = XTIC + 2147483647.000
        Calc YTIC = YTIC + 7147483647.000
        Calc XTIC = XTIC (÷)1000
        Calc YTIC = YTIC (÷)1000
5.  Transform (coverage) (coverage)1
6.  Build (coverage)1 Line
7.  Renamcov (coverage)1 (coverage)2
8.  Additem (coverage)2.AAT (coverage)2.AAT Level 45B
9.  Build (coverage)Good Line
10. Info
        Sel (coverage)2.AAT
        Rel (coverage)2.GAT by (coverage)2# with Link
        Calc Level = $1 Level
11. Kill (coverage)All
```

ENERGY RESOURCES CONSERVATION BOARD (ERCB)

Two types of ERCB data were used for the demo; the coal permit and coal mine graphic files; and the oil and gas well locations from the ERCB well data file. The two types of data were transformed and imported to pcARC/INFO using a number of small custom formating programs written in fortran. When the data files were in a format that pcARC/INFO could recognize they were coverted to coverages.

Format of the ERCB Data

The data is provided in three standard VAX/VMS files on tape at 6250 bpi. The file names, in the order that they appear on the tape are cmg.out, bs2.out and cbl.out. The files contain variable length records with a maximum record length of 313 bytes. The format of the records in these files is described in the following section.

1. LINE

1.1	CODE	cc 01-04	I4	The code for LINE records is "3".
1.2	LEVEL	cc 05-07	I3	Level or data type number of graphic element
1.3	LINE CODE	cc 08-10	I3	Line code of graphic element
1.4	START X CO-ORD	cc 11-21	F11.3	Meters
1.5	START Y CO-ORD	cc 22-32	F11.3	Meters
1.6	STOP X CO-ORD	cc 33-43	F11.3	Meters
1.7	STOP Y CO-ORD	cc 44-54	F11.3	Meters

2. ARC

2.1	CODE	cc 01-04	I4	The code for ARC records is "16".

2.2	LEVEL	cc 05-07	I3	Level or data type number of graphic element
2.3	LINE CODE	cc 08-10	I3	Line code of graphic element
2.4	START X CO-ORD	cc 11-21	F11.3	Meters
2.5	START Y CO-ORD	cc 22-32	F11.3	Meters
2.6	START ANGLE	cc 33-40	F8.3	Degrees
2.7	SWEEP ANGLE	cc 41-48	F8.3	Degrees
2.8	RADIUS	cc 49-59	F11.3	Meters

3. TEXT

3.1	CODE	cc 01-04	I4	The code for TEXT records is "17".
3.2	LEVEL	cc 05-07	I3	Level or data type number of graphic element
3.3	LINE CODE	cc 08-10	I3	Line code of graphic element
3.4	START X CC-ORD	cc 11-21	F11.3	Meters
3.5	START Y CC-ORD	cc 22-32	F11.3	Meters
3.6	TEXT ANGLE	cc 33-40	F8.3	Degrees
3.7	TEXT HEIGHT	cc 41-47	F7.3	Meters
3.8	TEXT WIDTH	cc 48-54	F7.3	Meters
3.9	NUMBER OF CHARS	cc 55-57	I3	Maximum value is 80
3.10	FILLER	cc 58	X	
3.11	TEXT	cc 59-138	80A1	This is a varying length record.

4. SYMBOL (CADASTRAL)

4.1	CODE	cc 01-04	I4	The code for symbol records is "2".
4.2	LEVEL	cc 05-07	I3	Level or data type number of graphic element
4.3	LINE CODE	cc 08-10	I3	Line code of graphic element
4.4	START X CO-ORD	cc 11-21	F11.3	Meters
4.5	START Y CO-ORD	cc 22-32	F11.3	Meters

5. NON-GRAPHIC DATABASE ELEMENTS

5.1	CODE	cc 01-04	I4	The code for NON-GRAPHIC records is "18".
5.2	LEVEL	cc 05-07	I3	Level or data type number of graphic element
5.3	LINE CODE	cc 08-10	I3	Line code of graphic element
5.4	START X CO-ORD	cc 11-21	F11.3	Meters
5.5	START Y CO-ORD	cc 22-32	F11.3	Meters
5.6	TEXT ANGLE	cc 33-40	F8.3	Degrees
5.7	TEXT HEIGHT	cc 41-47	F7.3	Meters
5.8	TEXT WIDTH	cc 48-54	F7.3	Meters
5.9	NUMBER OF CHARS	cc.55-57	I3	Maximum value is 255
5.10	FILLER	cc 58	X	
5.11	TEXT	cc 59-313	25A1	This is a varying length binary (unformatted record)

Note: This record type will follow the graphic element that this data is associated with. If more than one graphic element share a

database element then that data will be replicated for each graphic element. The level and line code fields are described below.

Level	Line Code	Meaning
12	13	Restricted Development Area
	15	Federal Park Boundaries
	16	Provincial Park Boundaries
	17	Indian Reserves
	18	Military Reserves
	19	Roads
	20	Railways
14	1	Surface Mine
	2	Underground Mine
	3	Uncertain Mine Location
	5	Mine Symbol Number
23	4	Mine Licence/Permit Number
	5	Mine Number
	24	Licences
	25	Permits
	26	Mined Out Areas

The text field of a nongraphic database record where the level = 14 is formatted as:

10 A	Underground Mine
10 A	Surface Mine
10 A	Uncertain Mine
1 X	Filler

The text field of a nongraphic database record where the level = 23 is formatted as:

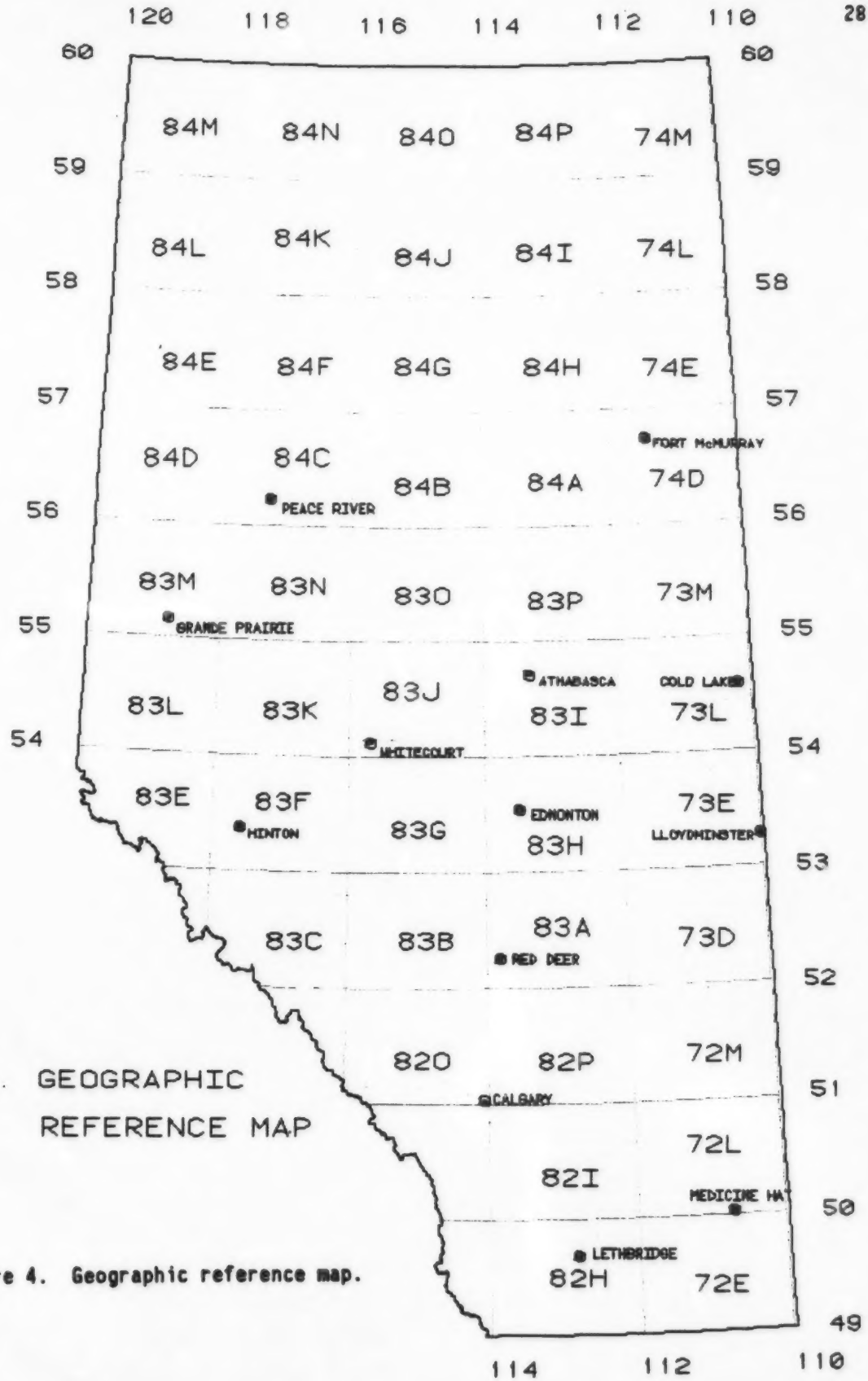
15 A	Mine Number
14 A	Licence Number
14 A	Permit Number
1 X	Filler

TRANSALTA UTILITIES (TAU)

Much of the coal and geological information was supplied by TAU. Most information was in hardcopy map form and required digitizing. Some information, particularly the coal quality information from Highvale, was in digital form; and was imported directly to PC INFO.

OTHER

Selected information from literature (Mills, 1987) and public maps (Alberta Energy, 1986) was collected and digitized. Based on Alberta Energy maps, coal lease information was digitized for NTS map sheet 83G.



MAP 1. GEOGRAPHIC REFERENCE MAP

Figure 4. Geographic reference map.

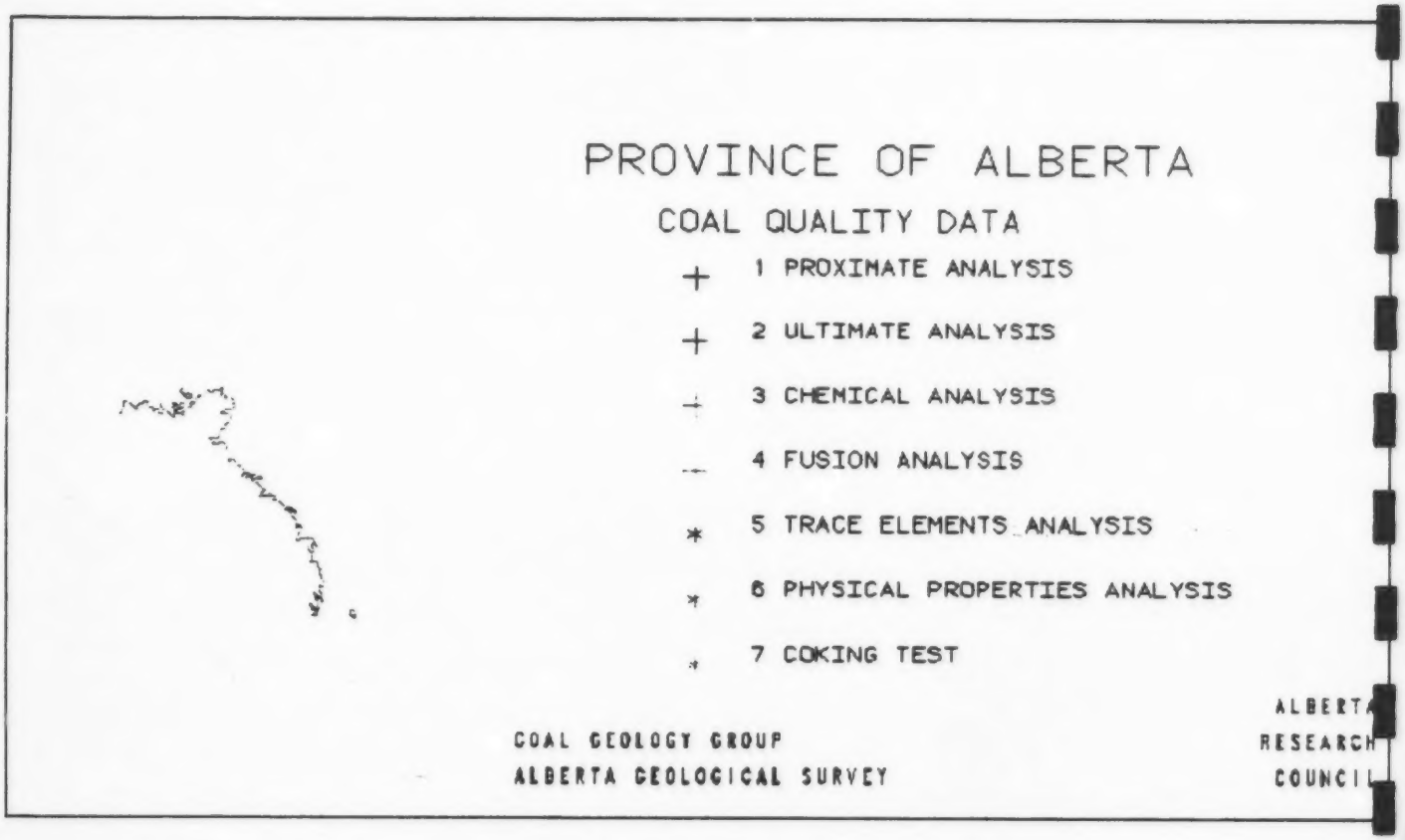


Figure 5. Provincial coal quality query screen.

USING THE PILOT DEMO

STARTING THE DEMO

Instructions for starting the demo can be found in Appendix 1. Within the demo it is possible to go to any level, print a map, query the data or quit without any knowledge of pcARC/INFO commands.

LEVEL 1: PROVINCIAL SCALE

The system can be queried for available information; figures 4 and 5 provide two views of base map information contained in the system.

Figure 4 contains the outlines of the 1:250 000 NTS map areas in Alberta with major cities and rivers providing a geographic reference. In addition, the provincial boundaries and lines of latitude/longitude are shown. Some of this information was also used in constructing the coal quality query screen shown in figure 5.

Figure 5 shows the subcrops of the Ardley and Horseshoe Canyon coals and indicates presence of available coal quality information. Items can be queried individually for the whole map area or for a small subarea by using the "zoom" function of pcARC/INFO. Individual data locations or alternately, all locations selected can have attribute information displayed as tables. The attribute information is attached to the data locations. In the Coal demo only the ERCB and AGS Coal Data Base (Richardson et.al., 1989) ID-key numbers are available. In addition, more than one type of information can be queried and displayed at once. Boolean operations are also possible. Figure 6 displays locations with proximate analysis data and trace element analysis. A hardcopy plot or a quick colour screen dump, such as figure 6, can be produced at any time at any menu level.

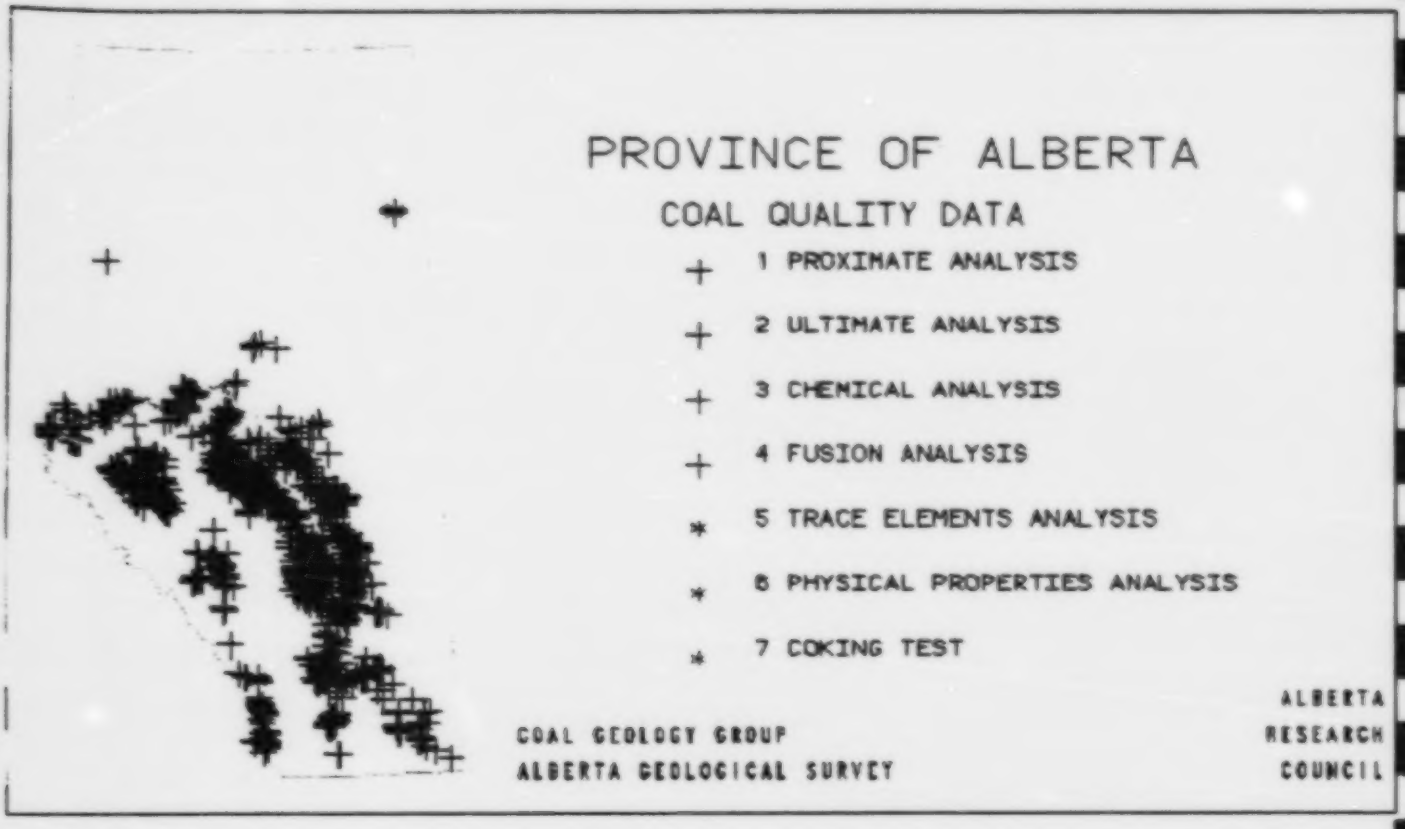


Figure 6. Proximate and trace element data distribution.

LEVEL 2: NTS 1:250 000 SCALE MAP AREAS

Provincial base map information such as lakes, rivers, and township grids (tables 3 and 4) is now available in a digital form from ABSM at a 1:250 000 scale. New digital maps at a scale of 1:20 000 will become available for the whole province gradually during the next decade; at present, less than half the province is available at the 1:20 000 scale. The base map information for Levels 2, 3 and 4 is based on the ABSM 1:250 000 scale data.

Figure 7 shows the Alberta Township Grid from ABSM. Once loaded into ARC/INFO the data can be used as a locational base for any subarea (figure 3). Other hardcopy maps, such as coal leases, can be digitized and integrated with the data (figure 8). Again, the data can be queried using the cursor and zoom feature; the data can also be used for further analysis or overlay creation.

Figure 9 is a screen dump of a 1:250 000 scale plotfile map that contains additional information legend not included in figure 8. The two figures showing the same information demonstrate both the capability and flexibility of the software to produce on-screen and/or hardcopy map products. Much more information can be displayed on the larger format hardcopy.

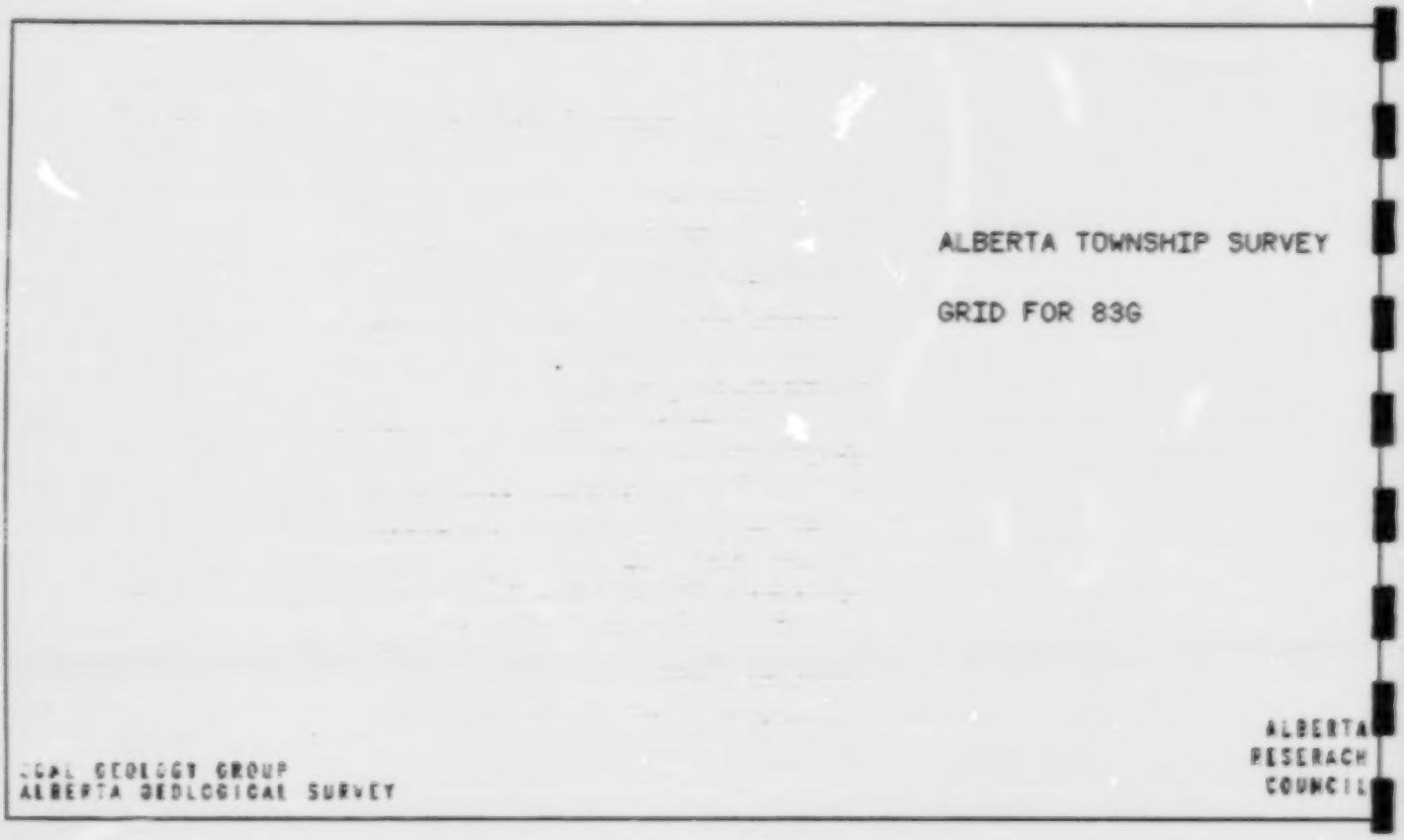


Figure 7. Alberta Township Survey for NTS Sheet 83G.

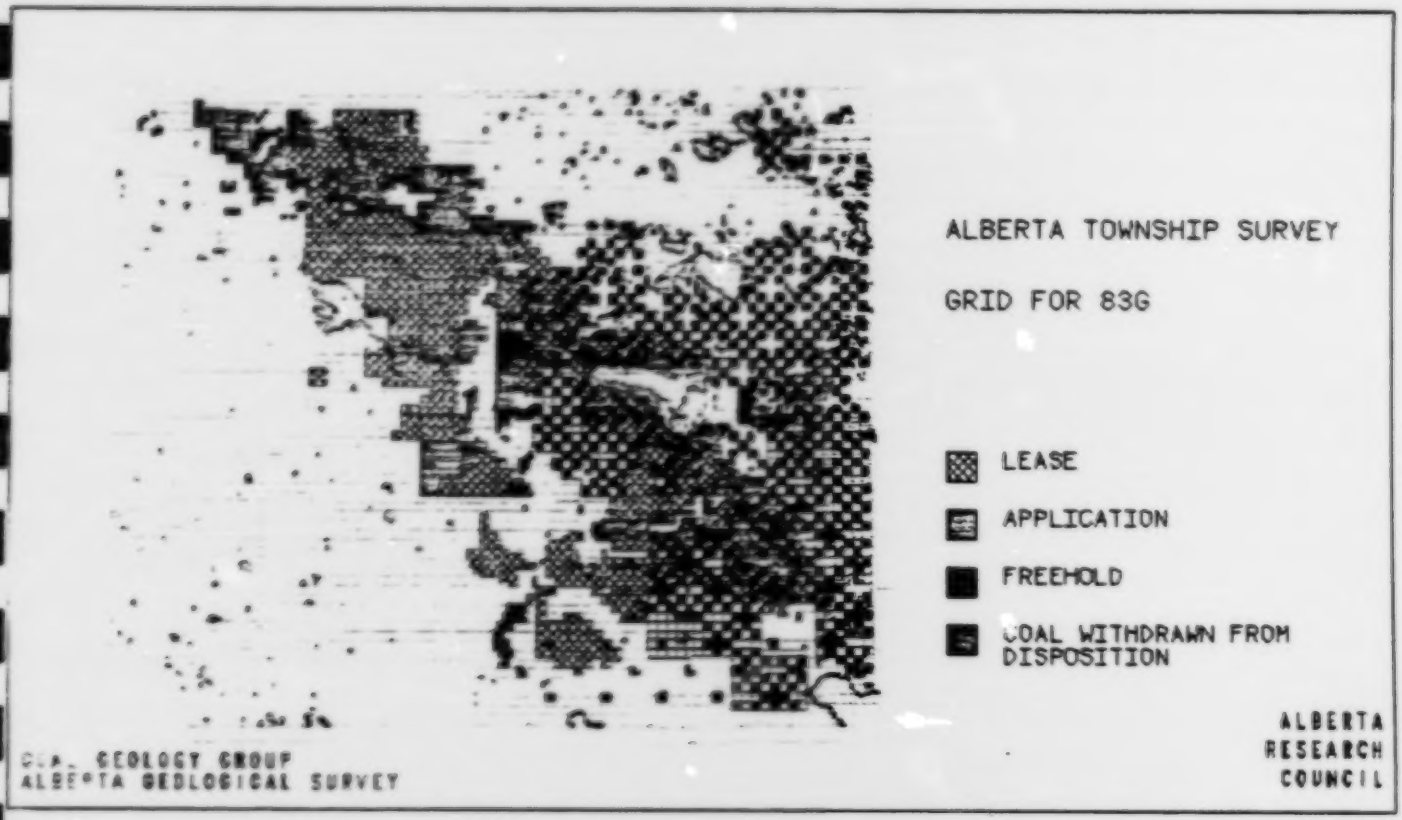


Figure 8. Coal lease data for NTS Sheet 83G.

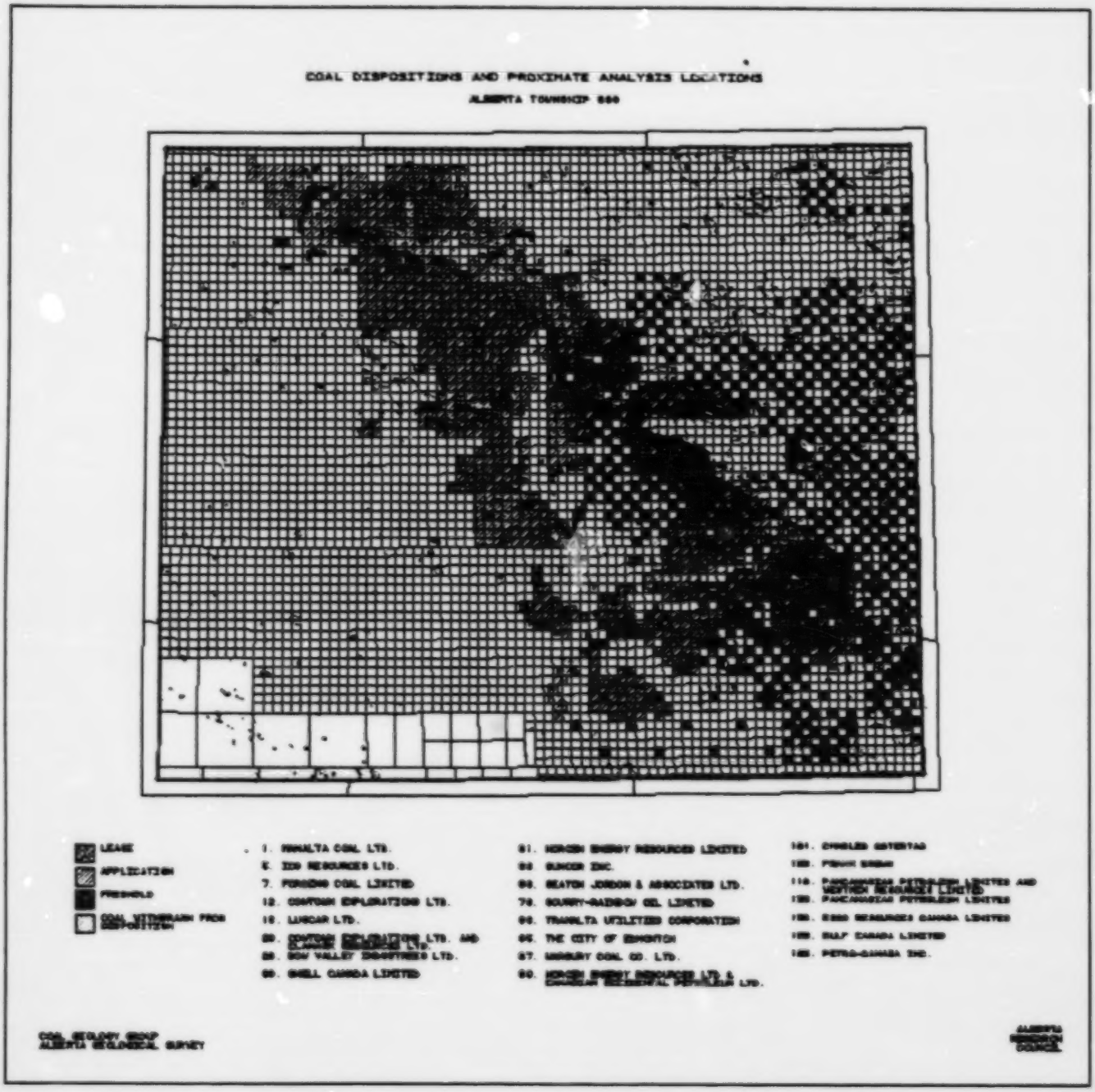


Figure 9. Plotfile map of coal lease data; NTS Sheet 83G.

LEVEL 3: SUBREGIONAL STUDY AREAS

The area selected for the pilot project demo's subregional study was the major thermal coal mining region near Lake Wabamun, west of Edmonton. At Level 3, provincial information can be merged to mine scale for overview display and analysis.

Based on the ABSM 1:250 000 digital data, details of the hydrography and its relationship to section outlines has been displayed in figure 10. Digital information on licenced areas (green) and oil and gas well locations (red dots) have been imported from the ERCB digital files. A 400 m development buffer zone for each oil and gas well has been automatically produced by the software. This demonstrates how GIS can be used to identify areas where resource development conflicts may occur between existing oil and gas wellsites (active or abandoned) and future coal mining. The demo can be queried on specific information related to the nature, status and ownership of the oil and gas wells. Abandoned or active wells can be easily distinguished. Since well status and licence information is available digitally the information can be easily updated.

Figure 11 demonstrates surface feature information (the wellsites) being integrated with subsurface resource information (coal isopachs) for use in resource management and/ or planning activities. Figure 11 shows the number of oil and gas wells and their areal distribution; the extent of potential resource conflict in terms of various seam thicknesses (Seam 1) and a radii of influence (400 m buffer zones) around each wellsite. The Seam-isopachs have been taken from Level 4 (the mine scale maps). On figure 11, the licence areas shown on figure 10 have been replaced by the actual mined out areas to demonstrate how different map elements can be combined. The colour of the well buffers were changed to black for clarity and to demonstrate how any polygon, line, or point can be modified.

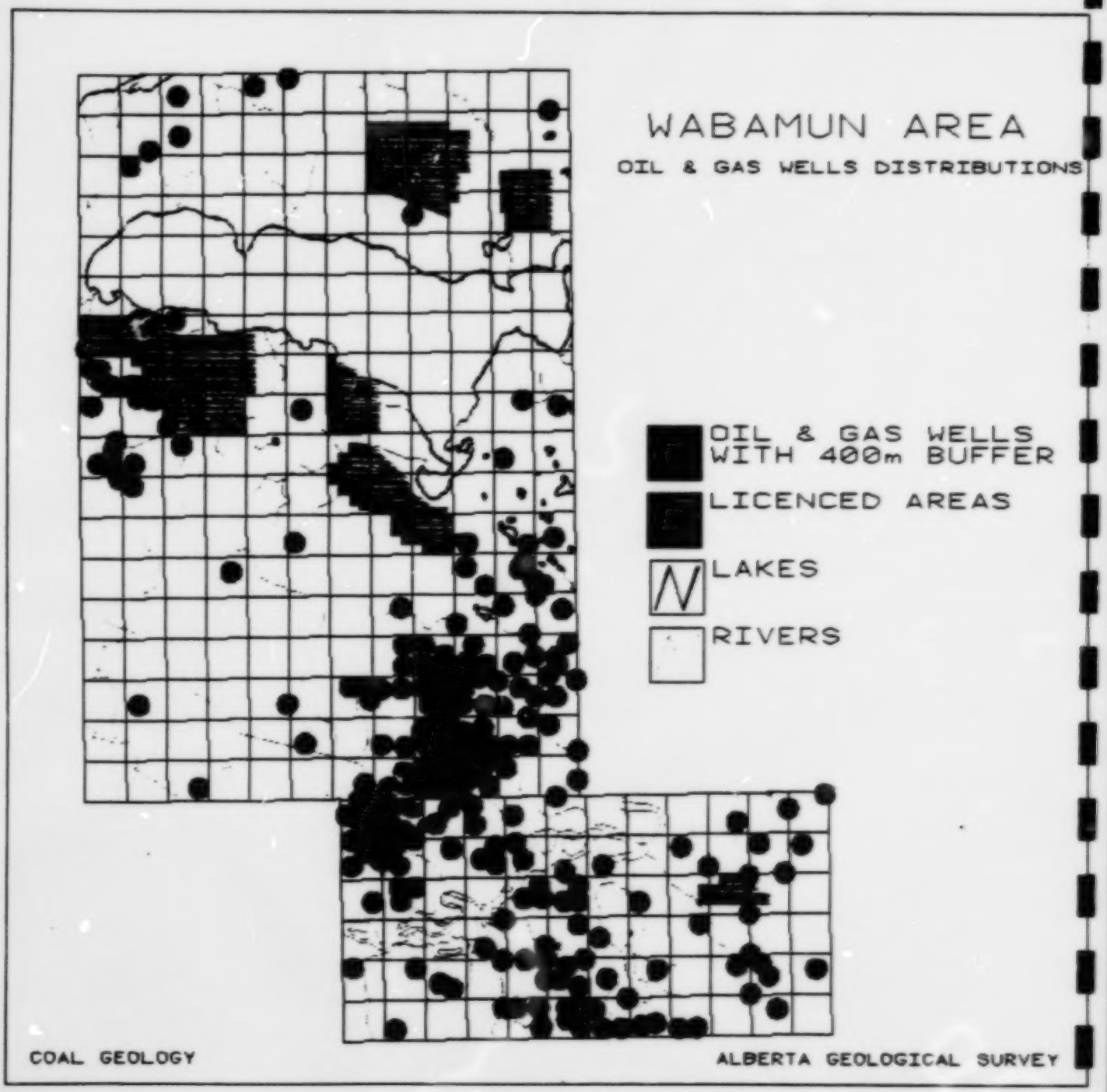


Figure 10. Oil and gas well 400 m buffers, Wabamun Area.

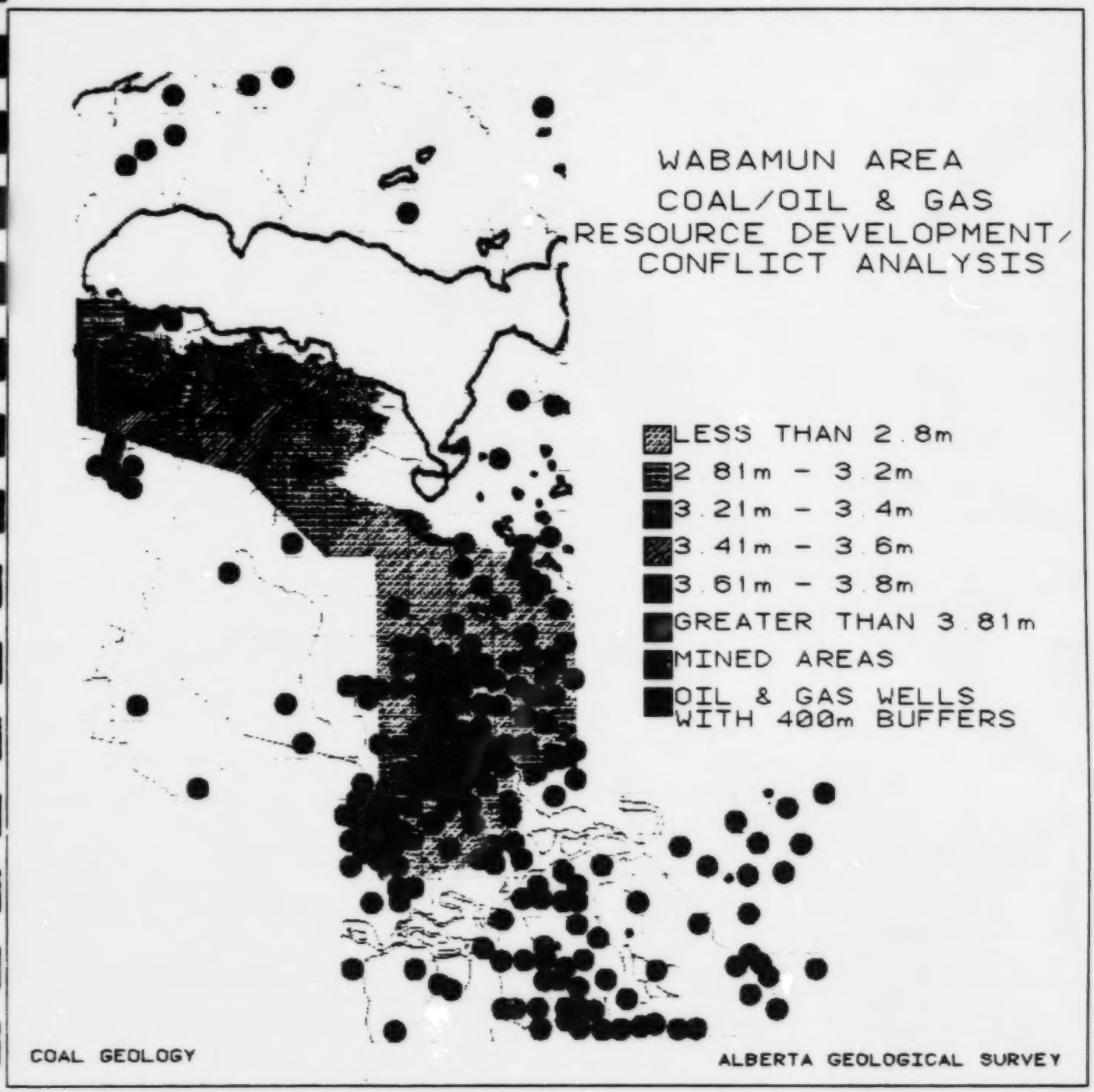


Figure 11. Coal/oil and gas resource development/conflict analysis.

LEVEL 4. TOWNSHIP AND MINE SITE DETAILED AREAS

In addition to much of the data previously discussed at Levels 1 to 3, detailed information on coal quality and geology is available at Level 4 The area to the north of the North Saskatchewan River in figure 12 has data density too high for detailed analysis. A mine scale map (figure 13) of the Southern Highvale, was located north of the North Saskatchewan River, allows for the identification of individual wells. This can be compared to an isopach of Seam 1 (figure 14).

Figure 15 displays a single township (Twp 50 R4 W5M) at Level 4 to show geological information; figure 16 displays the status of individual oil and gas wells for individual sections.

Coal quality data for individual seams (Seams 1 through 5) is available in the demo for the whole of the Highvale mine permit area (figure 17).

Figure 18 shows the permit and licence information for the Northern Highvale area.

Figures 19 through 21 also pertain to the Northern Highvale area and provide examples of bedrock, isopach and structural contour maps that are resident in the demo.

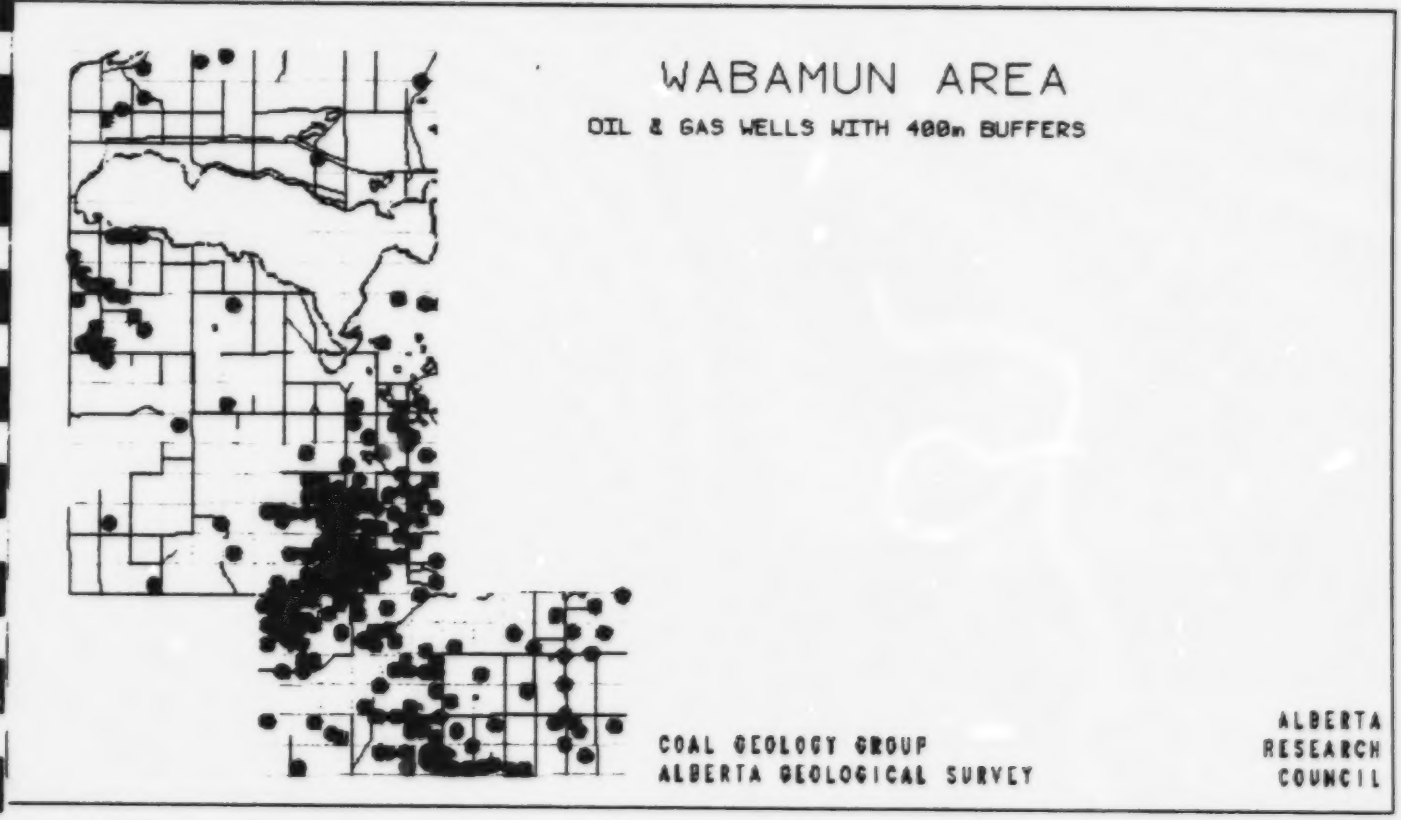


Figure 12. Wabamun Area: buffered wells with road network.

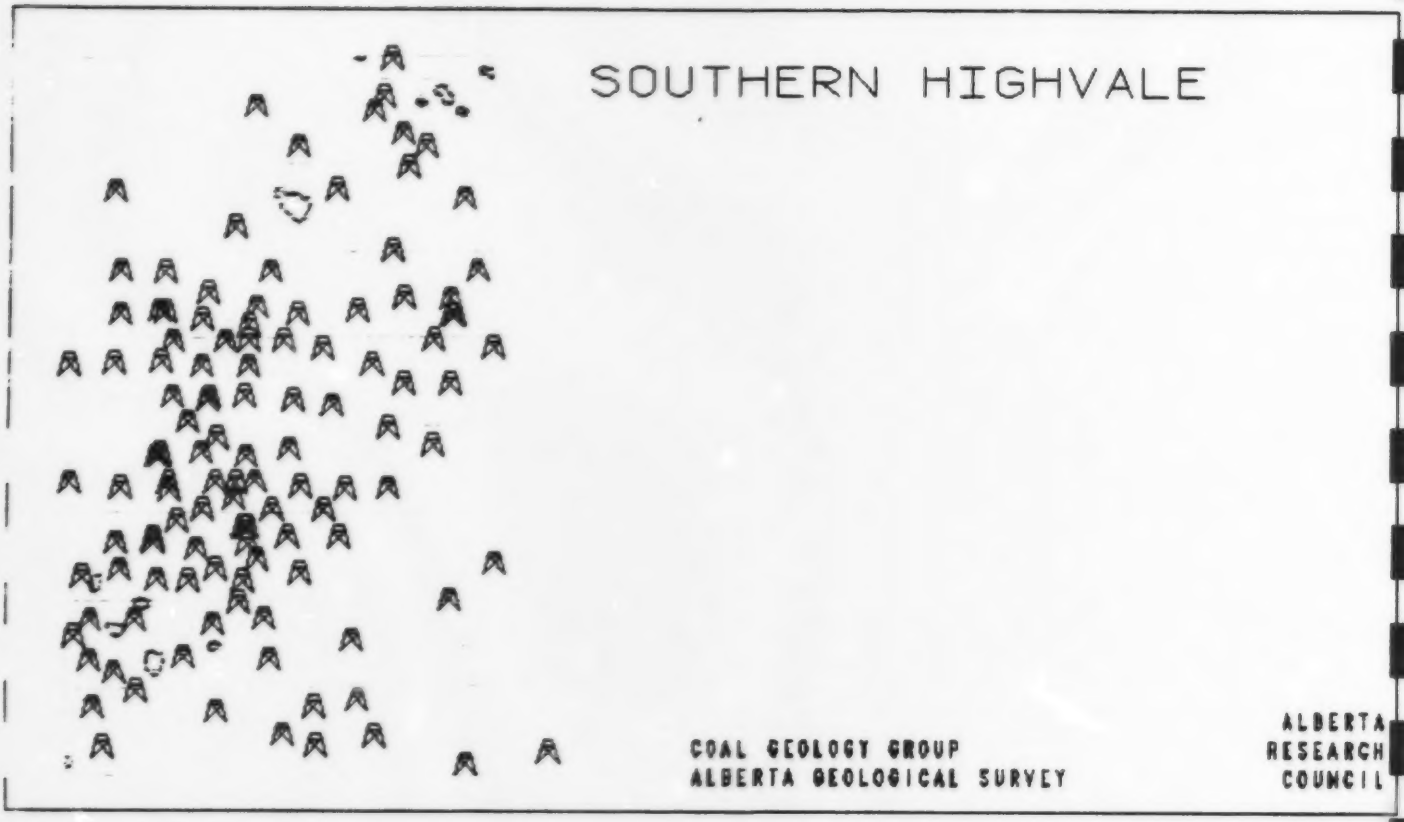


Figure 13. Southern Highvale oil and gas distribution.

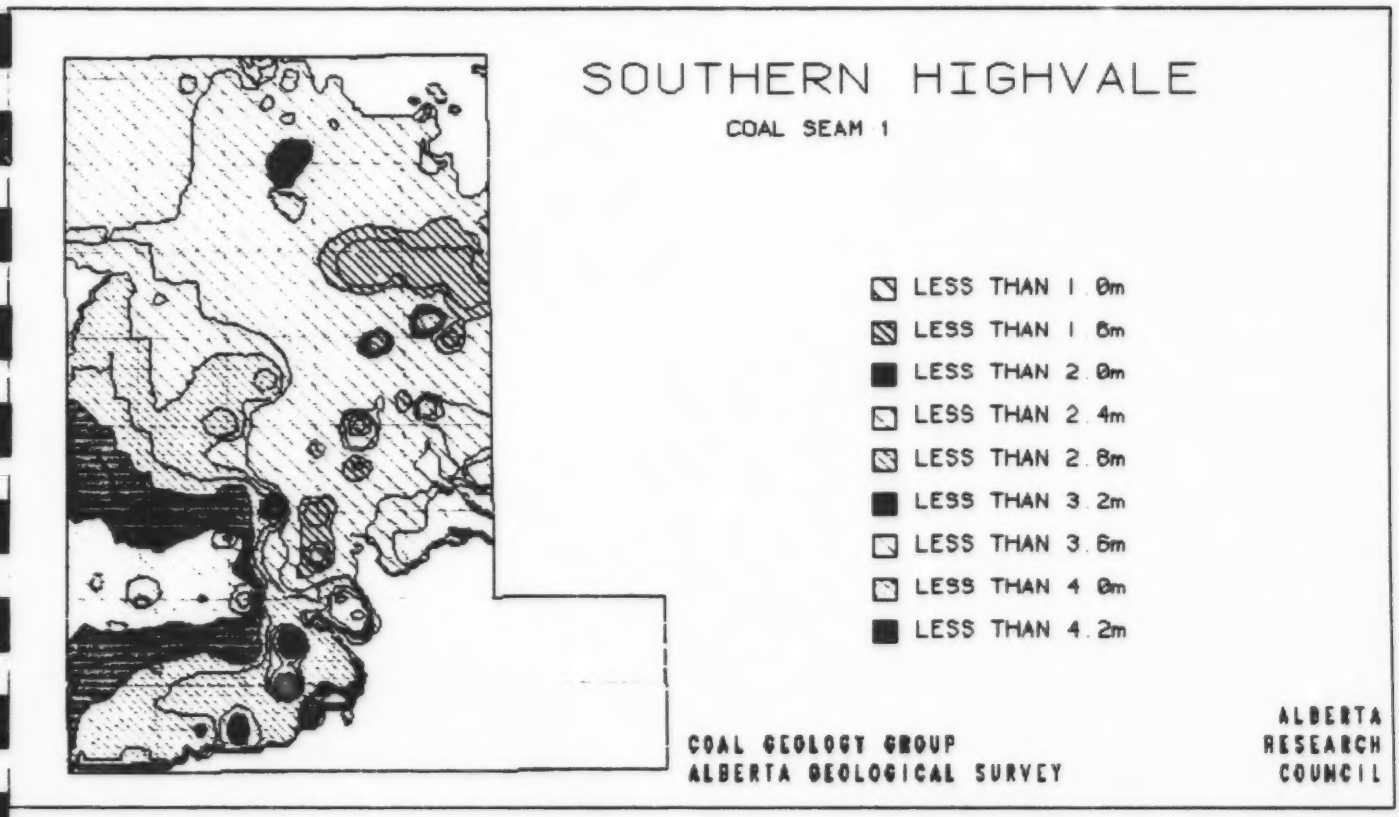
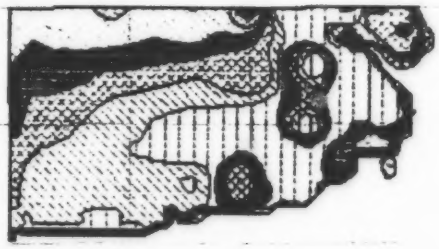


Figure 14. Southern Highvale isopach of Seam 1.



TWP: 5 50 4
HIGHVALE: COAL SEAM 1

- LESS THAN 1.6m
- LESS THAN 1.8m
- LESS THAN 2.0m
- LESS THAN 2.2m
- LESS THAN 2.4m
- LESS THAN 2.6m
- LESS THAN 2.8m
- LESS THAN 3.0m
- LESS TNAN 3.2m
- LESS THAN 3.4m
- LESS THAN 3.6m

COAL GEOLOGY GROUP, ALBERTA GEOLOGICAL SURVEY

ALBERTA RESEARCH COUNCIL

Figure 15. Township 50, Range 4, West of the 4th, isonach Seam 1.

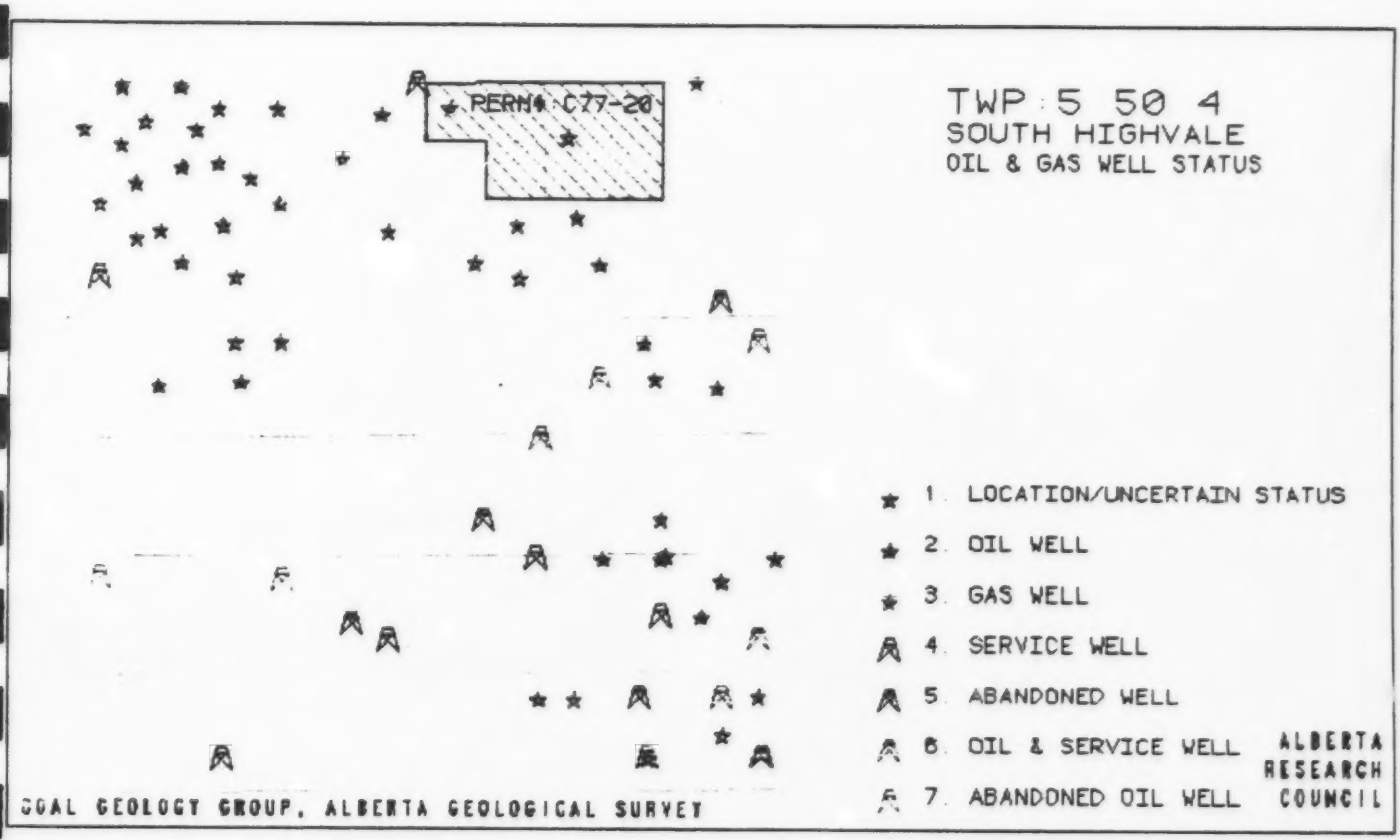


Figure 16. Township 50, Range 4, West of the 4th, Well Status.

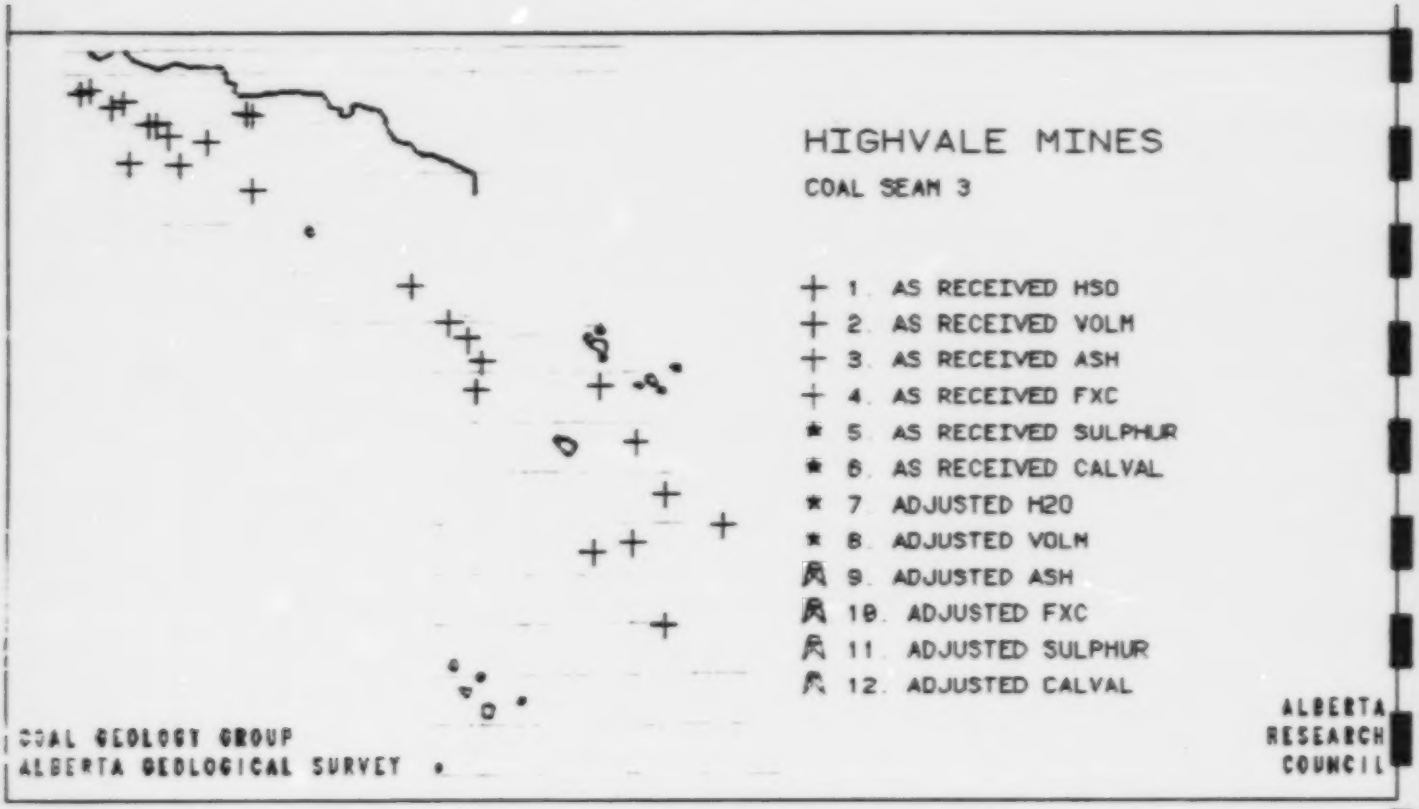


Figure 17. Highvale Area; as received volatile matter Seam 3.

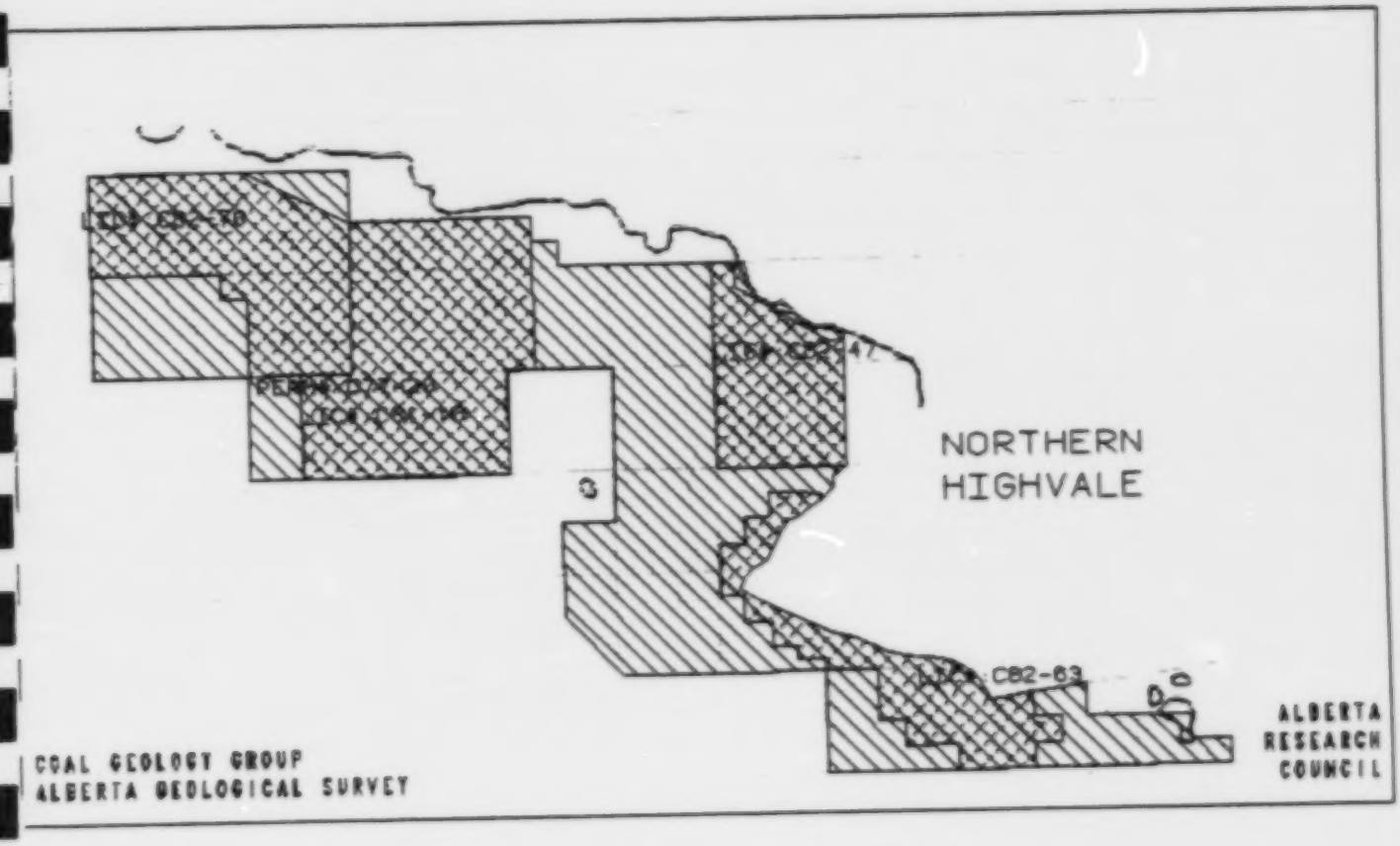


Figure 18. Northern Highvale permit and licence data.

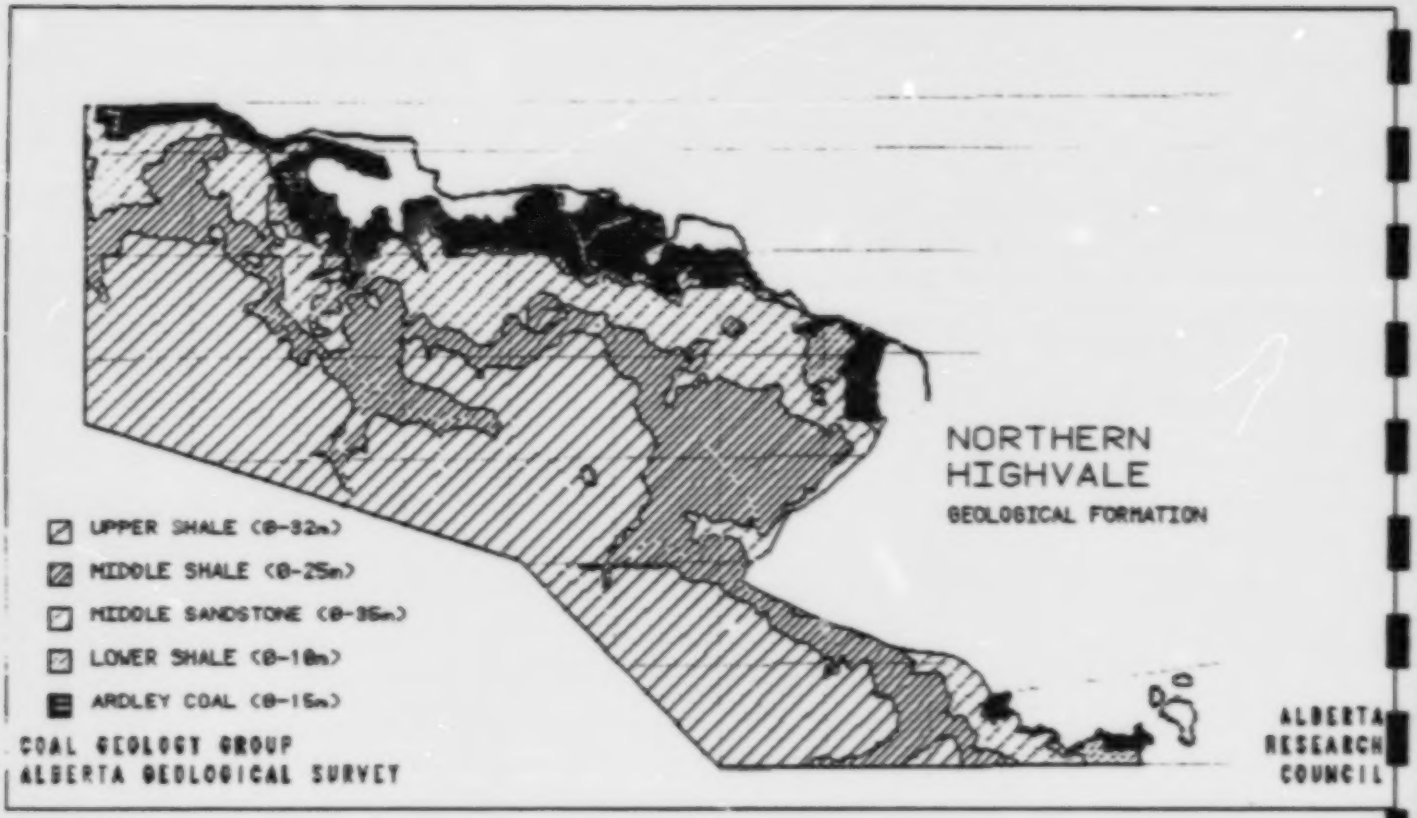


Figure 19. Northern Highvale geological map.

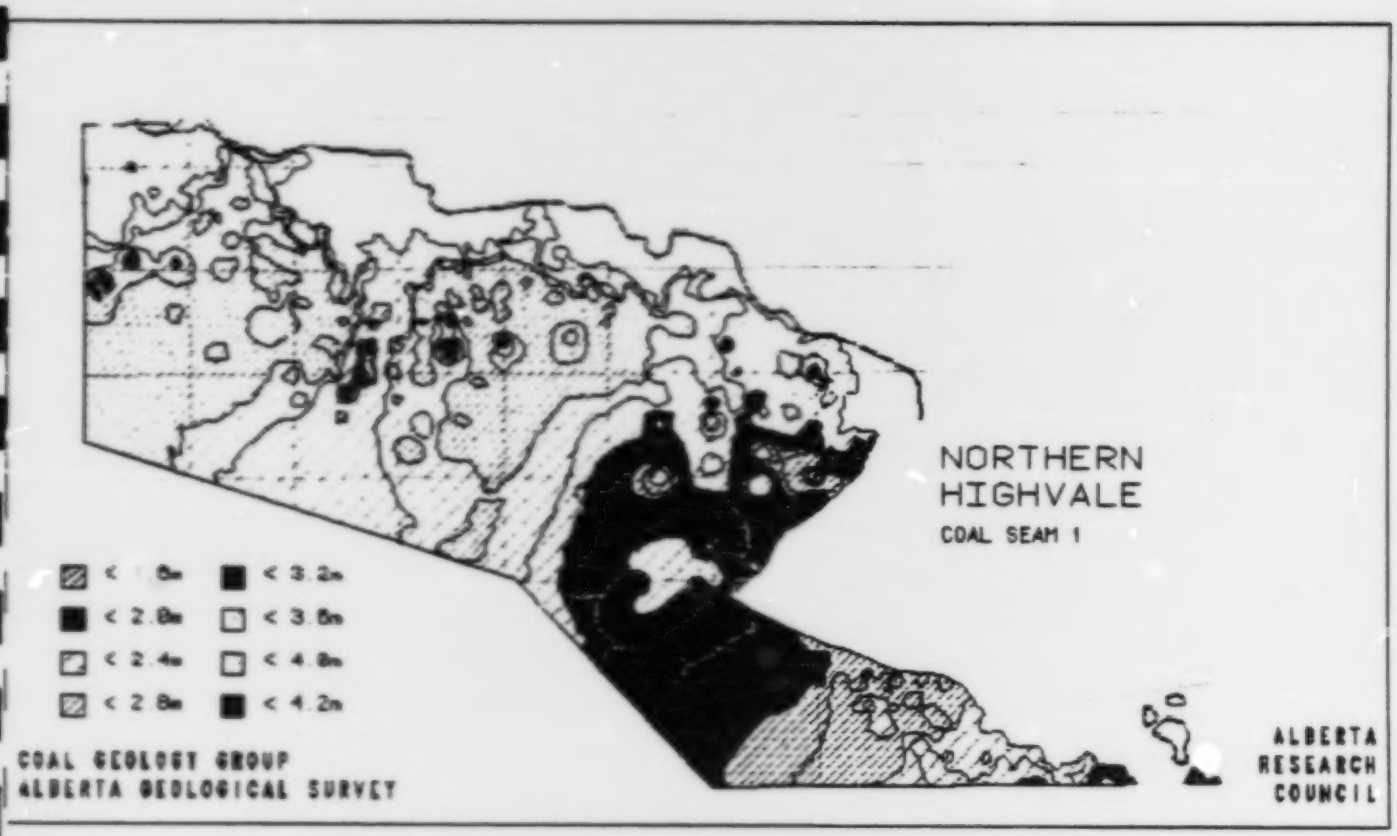


Figure 20. Northern Highvale isopach map of coal Seam 1.

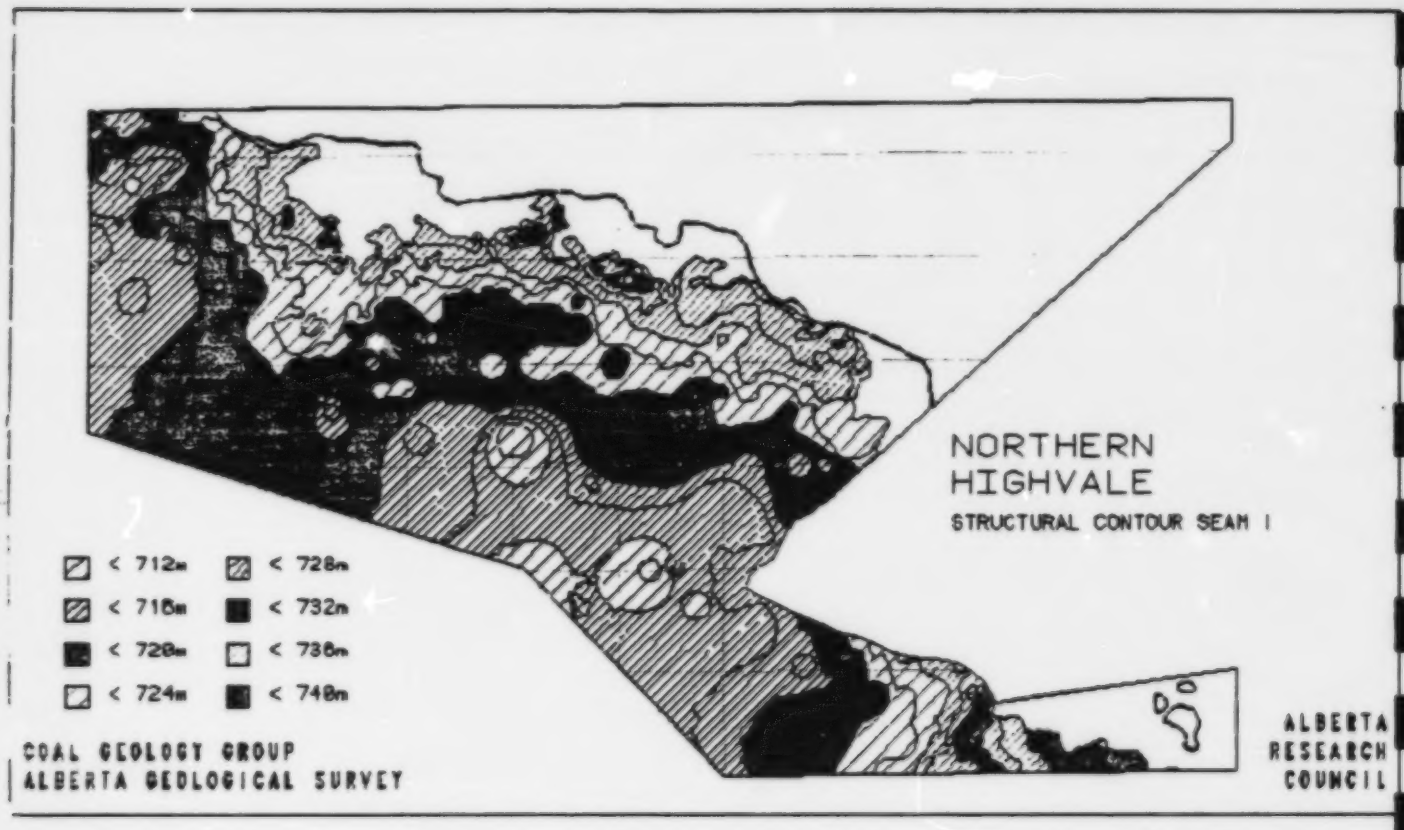


Figure 21. Northern Highvale structure contour map of coal Seam 1.

EXPERIENCE GAINED FROM STUDY

CAPABILITIES

The workstation and software combine to make a fully functional GIS system. Virtually all the features of a fully operational mini-computer based system were available on pcARC/INFO.

Hardware

The 386 machine was able to complete most of the required processing in a few minutes. The disk storage of space 300Mb. exceeded necessary requirements.

Software

The software was capable of handling all the basic GIS functions and a large number of advanced applications.

LIMITATIONS

Hardware

The MS-DOS operating system was a major limitation on the hardware. Machine resources failed when too many files were open or the 640Kb. of regular memory was filled. A failure to buffer 10 000 points (after a 10-hour run) may have been caused by a lack of available RAM or disk space for scratch files. ESRI notes that the scratch space required by BUILD/CLEAN can be from 4 to 13 times the coverage size and as a general rule-of-thumb: the greater the number of coordinates per arc and the greater the number of intersections, the more scratch space will be needed.

Software

The software does not allow access to extended or expanded memory. A limit of 20 open files at any time is too restrictive. The software produces a large number of files which could be cumbersome to handle, if most of the organization were not automatic.

ESRI notes that the total number of arcs per coverage is 32,000 (limit applies only to ADS, DIGITIZE and EDIT); with the number of points per arc and the number of arcs per polygon is limited to 500 and 5,000 respectively.

The software is 2-D in nature, while many geological problems are best dealt with in 3-D.

Manpower

An experienced operator is needed for all but the simplest tasks. Training is required to use and develop the pcARC/INFO system. The operator needs to be a dedicated component of the GIS effort.

SYSTEM DOCUMENTATION

ARC/INFO Files

Appendix 2 lists and describes the various ARC/INFO file types.

MS-DOS File Directory Path

Appendix 4 is a MS-DOS path directory of all files in the pilot demo. A study of this appendix provides a guide to the structure of the demo on a directory/subdirectory/file basis. The complexity of the file system can be readily seen. Figure 2, the data structure, provides a greatly simplified view of the demo when compared to appendix 4.

File Size and Occurrence

Appendices 5 and 6 provide additional detail on files, including the date and time of creation, the size in bytes, and the directory/file name and extension.

A total of 600 files comprise Levels 1 and 2 of the demo; 4,661 files were created for Levels 3 and 4. In total, 5,261 files more than 28Mb. of storage space comprise the demo.

The largest file was 1.6Mb. while the mean, median and mode for all files was 5382, 512, and 80Kb. respectively (table 5). A log frequency plot (figure 22) shows that file frequency decreases rapidly with increasing file size, i.e., the system produces a large number of small files.

Table 5.

Filename	N	Min	Max	Mean	Median	Mode	Skewness
ARC	2167	80	554240	3761.89	432	80	18.7445
CNT	142	512	27392	2469.86	1152	512	4.3242
LAB	205	512	1.58008×10^6	12569.0	768	512	13.4876
LNK	0	-	-	-	-	-	-
TIC	266	48	132	48.6316	48	48	11.4669
TXT	98	512	4352	728.816	512	512	3.6439
AAT	197	0	369152	9670.54	1520	28	7.1488
ADD	0	-	-	-	-	-	-
PAT	201	16	790160	13740.1	592	32	8.9758
TRN	0	-	-	-	-	-	-
ARF	30	28	171948	16193.3	3612	2352	3.5682
NRF	187	4	25136	652.5	132	4	7.7586
PAL	140	512	102144	6370.7	2560	512	5.1827
PRF	47	16	19632	962.04	128	32	5.9341
BND	441	4	5120	179.3	16	16	6.5813
LOG	294	24	7292	903.5	656	24	2.9955
MSK	5	512	768	614.4	512	512	0.6086
TOL	173	12	24	19.7	24	24	-0.6
GSISFILE	5261	0	1.5808×10^6	5381.61	512	80	18.7445
SML	44	51	18717	5159.36	3479	55	0.4828

Table 5. File size statistics.

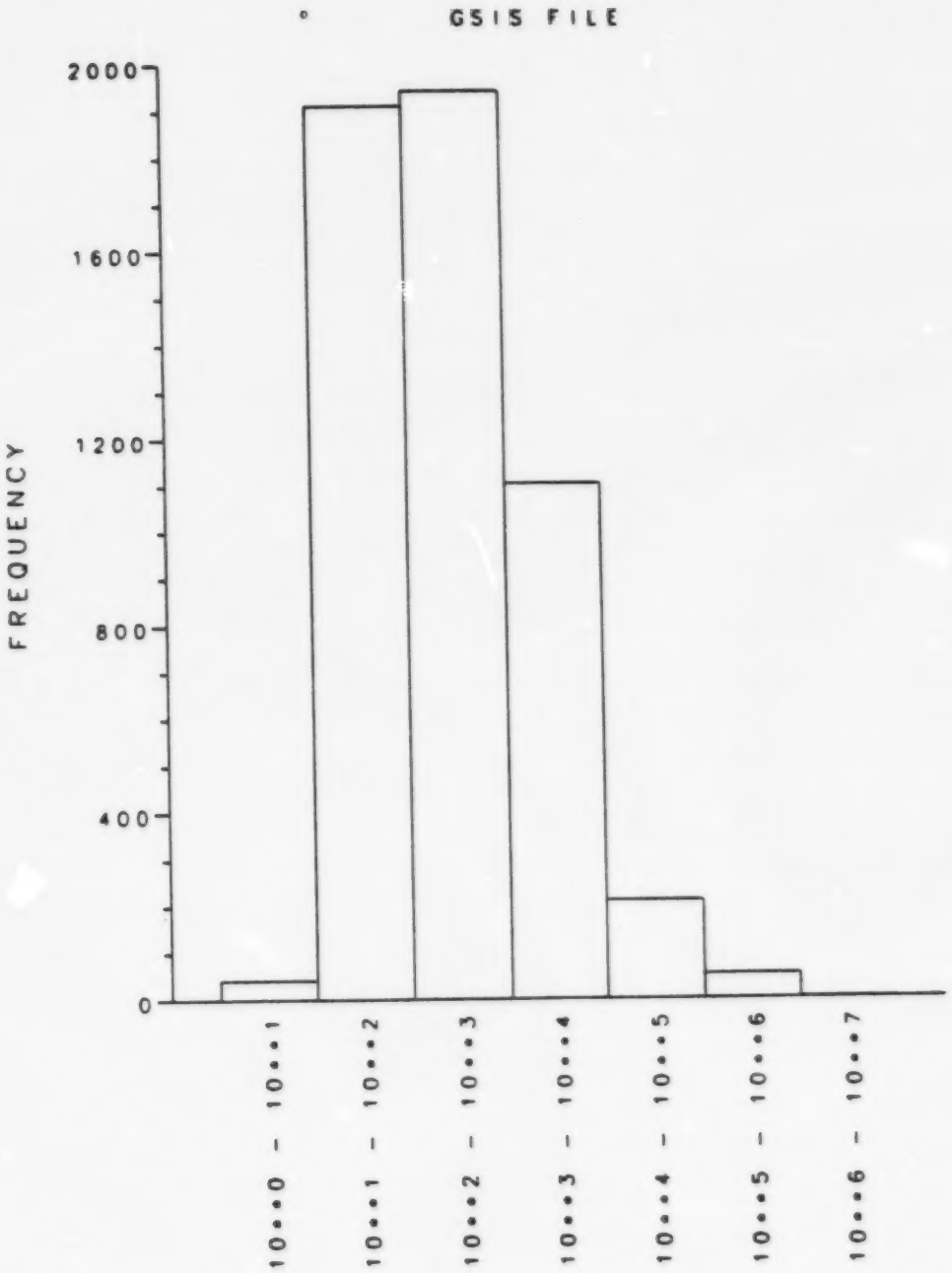


Figure 22. Frequency plot of demo file size.

Simple Macro Language (SML) Files

Appendix 7 is a complete listing of the SML files that make up the demo menu system. These files can be modified, compressed or adapted for other demos using the same or other ARC/INFO files.

SUMMARY

It is important to stress that it is the pilot project demo itself, not this report, that is the primary product of this project. The prime function of the project was to demonstrate the capabilities of a GIS system, as it pertains to enhancing and supporting the coal-related information requirements of the Alberta Geological Survey's Coal Geology Section as well as industry and government.

FUTURE PLANS

Future plans include the enhancement of the present GSIS system. The demo is currently being ported to an ARC/INFO environment of a minicomputer. Testing of the demo will begin in 1989-90, on the distributed system, to establish performance and costs. The existing PC-system will be kept operational and new data will be added from relevant Alberta Geological Survey's Coal Geology Section projects as the data becomes available. Substantial effort will be spent on developing the reporting and querying capabilities.

A project has been approved for 1989-90 for the development of a operational Geoscience Information System (GSIS) which will form the foundation of the Alberta Geological Survey's Coal Geology Section spatial data storage, display and analysis. This project will allow the Coal Geology Section and the Alberta Geological Survey to more thoroughly fulfill its mandate by achieving the following goals:

1. Help establish an Alberta-wide electronic map library of existing map data, consisting in part of base maps (planimetric, topographic and geologic), ERCB coalfield maps,

Alberta Energy's Coal Lease Maps, maps from the Alberta Geological Survey's Plains evaluation studies and maps from selected coal geology papers.

2. Convert the Alberta Geological Survey's Coal Data Base data into GIS format, i.e. build point coverages of all drill hole information with the GIS database attached.

3. Link the GSIS to the Alberta Geological Survey's Coal Data Base.

4. Build a user interface system to: (i) allow common queries to be facilitated by a menu system and (ii) allow data and maps commonly needed in geological survey, coal exploration, and resource evaluations to be facilitated by a menu system.

5. Establish links between other software such as statistical, mapping and geostatistical packages.

6. Establish links to the Provincial LRIS system.

REFERENCES

ESRI manuals for pcARC/INFO. 1987 and 1988.

Richardson, R.J.H., Mandryk, G.B., and Fietz, D.W., 1989. Coal Geology Data Base, Alberta Research Council Open File Report 1989-02A, B, C,and D. 473 pages.

DATA STRUCTURE LEVELS 1 AND 2

C:\PROJ1

- ERCBQLT
- ERCB_AB
- OILw83G
- 83G_NW
- 83G_NE
- 83G_SW
- 83G_SE
- 83G
- AT3
- RIV
- LAK
- HWY
- SET
- MDB
- MINED
- OILBUF
- QLTAB.SML
- 83G.SML
- WELCOME.SML
- ABQLT.KEY
- 83G.KEY

Legend

BND	- Township boundary
ATS	- Alberta township survey grid
RIV	- Rivers
LAK	- Lakes
HWY	- Roadways
SET	- Reserve and park boundaries and railroads
MDB	- Municipal district boundaries - county boundaries
HIS01	- Highvale Mine (N&S) - Isopach of seam 1 (ISO1)
HIS02	- Highvale Mine (N&S) - Isopach of seam 2 (ISO2)
HINGEOL	- Highvale Mine (N) - Geological map (GEOL)
HSLS	- Highvale Mine (S) - Isopach of unit 80 (lower shale) (ISOLS)
HSDBED	- Highvale Mine (S) - Isopach - Surface to top lithology 500 (DBED) - (base of disturbed bedrock)
GHSC	- Genesee Mine - Top of highest seam contours (HSC)
GDRILLH	- Genesee Mine - Drillhole distribution (DRILLH)
GTUM	- Genesee Mine - Top of upper main (TUM)
GSCLM	- Genesee Mine - Sulphur contours - lower main (SCLM)
GDCLM	- Genesee Mine - Depth of cover to lower main (DCLM)
GTLM	- Genesee Mine - Top of lower main contour (TLM)
GACHS	- Genesee Mine - Ash contours: high seam (ACHS)
GACLM	- Genesee Mine - Ash contours: lower main (ACLM)
GSCHS	- Genesee Mine - Sulphur contours - high seam (SCHS)
GOTC	- Genesee Mine - Overburden thickness (OTC)
WISO1	- Whitewood Mine - Isopach of seam 1 (ISO1)
WISO3	- Whitewood Mine - Isopach of seam 3 (ISO3)
WFMS	- Whitewood Mine - Isopach of overburden to first mineable seam (FMS)
WSCT3	- Whitewood Mine - Structural contour: top of seam 3 (SCT3)
LIC	- Licenced areas
PERM	- Permit areas
MINED	- Mined-out areas
UNDER	- Underground mines - point
SURF	- Surface mines - point
UNCERT	- Uncertain
STAT	- Well status - point
HNSC1	- Highvale Mine (N) - Structural contours seam 1 (SC1)
ERCBQLT	- Provincial coal quality
ERCB_AB	- Outline of province of Alberta
OILW83G	- Oil well locations at 83G
83G_NW	- Coal dispositions at 83G northwest
83G_NE	- Coal dispositions at 83G northeast
83G_SW	- Coal dispositions at 83G southwest
83G_SE	- Coal dispositions at 83G southeast
83G	- Coal dispositions at 83G
OILBUF	- Oil wells with 400 m buffers at 83G
OVB	- Overburden
SMPCD	- Sample code
HVPNT	- Highvale coal drillhole locations

DATA STRUCTURE LEVELS 3 AND 4

C:\WABAMUN

- TWPS
  - T5355
    - BND
    - ATS
  - T5345
    - BND
    - ATS
  - T5255
    - BND
    - ATS
  - T5245
    - BND
    - ATS
  - T5155
    - BND
    - ATS
  - T5145
    - BND
    - ATS
  - T5045
    - BND
    - ATS
  - T5035
    - BND
    - ATS
- SAREA
  - BND
  - ATS
- MINES
  - HIGHVA
    - ISO1
    - ISO2
  - HIGHVN
    - ISO1
    - ISO2
  - HIGHVS
    - ISO1
    - ISO2
  - WHITE
    - ISO3
    - SCT3
  - GEN
    - HSC
    - TUM

DATA STRUCTURE LEVELS 1 AND 2

C:\PROJ1

- ERCBQLT
- ERCB_AB
- OILw83G
- 83G_NW
- 83G_NE
- 83G_SW
- 83G_SE
- 83G
- AT3
- RIV
- LAK
- HWY
- SET
- MDB
- MINED
- OILBUF
- QLTAB.SML
- 83G.SML
- WELCOME.SML
- ABQLT.KEY
- 83G.KEY

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HIS02	- Highvale Mine (H&S) - Isopach of seam 2 (ISO2)
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HSLS	- Highvale Mine (S) - Isopach of unit 80 (lower shale) (ISOLS)
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GTLM	- Genesee Mine - Top of lower main contour (TLM)
GACHS	- Genesee Mine - Ash contours: high seam (ACHS)
GACLM	- Genesee Mine - Ash contours: lower main (ACLM)
GSCHS	- Genesee Mine - Sulphur contours - high seam (SCHS)
GOTC	- Genesee Mine - Overburden thickness (OTC)
WISO1	- Whitewood Mine - Isopach of seam 1 (ISO1)
WISO3	- Whitewood Mine - Isopach of seam 3 (ISO3)
WFMS	- Whitewood Mine - Isopach of overburden to first mineable seam (FMS)
WSCT3	- Whitewood Mine - Structural contour: top of seam 3 (SCT3)
LIC	- Licenced areas
PERM	- Permit areas
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SURF	- Surface mines - point
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83G_NE	- Coal dispositions at 83G northeast
83G_SW	- Coal dispositions at 83G southwest
83G_SE	- Coal dispositions at 83G southeast
83G	- Coal dispositions at 83G
OILBUF	- Oil wells with 400 m buffers at 83G
OVB	- Overburden
SMPCD	- Sample code
HVPNT	- Highvale coal drillhole locations

DATA STRUCTURE LEVELS 3 AND 4

C:\WABAMUN

- TWPS
  - T5345
    - BND
    - ATS
  - T5255
    - BND
    - ATS
  - T5245
    - BND
    - ATS
  - T5155
    - BND
    - ATS
  - T5145
    - BND
    - ATS
  - T5045
    - BND
    - ATS
  - T5035
    - BND
    - ATS
- SAREA
  - BND
  - ATS
- MINES
  - HIGHVA
    - ISO1
    - ISO2
  - HIGHVN
    - ISO1
    - ISO2
  - HIGHVS
    - ISO1
    - ISO2
  - WHITE
    - ISO3
    - SCT3
  - GENE
    - HSC
    - TUM

DATA STRUCTURE LEVELS 3 AND 4
C:\WABAMUN

- TWPS
  - T5355
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - SET
    - MDB
    - STAT
    - HISO1
    - HISO2
    - HINGEOL
    - HINSC1
    - WISO3
    - WFMS
    - WSCT3
    - UNDER
    - UNCERT
    - SURF
    - MANUAL.SML
    - PRINTER.SML
  - T5345
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - SET
    - MDB
    - STAT
    - WISO3
    - WFMS
    - WSCT3
    - MINED
    - PERM
    - LIC
    - UNDER
    - UNCERT
    - SURF
    - MANUAL.SML
    - PRINTER.SML
  - T5255
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - STAT
    - HISO1
    - HISO2
    - HINGEOL
    - HINSC1
    - MINED
    - PERM
    - LIC
    - SURF
    - MANUAL.SML
    - PRINTER.SML
  - T5245
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - SET
    - STAT
    - HISO1
    - HISO2
    - HINGEOL
    - HINSC1
    - HSLS
    - HSDBED
    - MINED
    - PERM
    - LIC
    - UNDER
    - UNCERT
    - SURF
    - MANUAL.SML
    - PRINTER.SML
  - T5155
    - BND
    - ATS
    - RIV
    - HWY
    - STAT
    - MANUAL.SML
    - PRINTER.SML
  - T5145
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - STAT
    - HISO1
    - HISO2
    - HSLS
    - HSDBED
    - PERM
    - MANUAL.SML
    - PRINTER.SML
  - T5045
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - MDB
    - STAT
    - HISO1
    - HISO2
    - HSLS
    - HSDBED
    - PERM
    - MANUAL.SML
    - PRINTER.SML
  - T5035
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - MDB
    - STAT
    - GHSC
    - GDRILLH
    - GTUM
    - GSCLM
    - GDCLM
    - GTLM
    - GACHS
    - GACLM
    - GSCHS
    - GOTC
    - LIC
    - PERM
    - UNCERT
    - SURF
    - MANUAL.SML
    - PRINTER.SML
- SAREA
  - BND
  - ATS
  - RIV
  - LAK
  - HWY
  - SET
  - MDB
  - STAT
  - LIC
  - PERM
  - MINED
  - UNDER
  - UNCERT
  - SURF
  - OILBUF
  - PRINTER.SML
  - MANUAL.SML
- MINES
  - HIGHVA
    - ISO1
    - ISO2
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - SET
    - MDB
    - STAT
    - HVPNT
    - MINED
    - PERM
    - LIC
    - UNDER
    - SURF
    - UNCERT
    - SEAM1.SML
    - SEAM2.SML
    - SEAM3.SML
    - SEAM4.SML
    - SEAM5.SML
    - SEAM6.SML
    - MANUAL.SML
    - HV2.SML
    - OVB
    - SMPCD
    - PRINTER.SML
  - HIGHVN
    - ISO1
    - ISO2
    - GEOL
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - SET
    - STAT
    - SC1
    - MINED
    - PERM
    - LIC
    - UNDER
    - SURF
    - UNCERT
    - MANUAL.SML
    - PRINTER.SML
  - HIGHVS
    - ISO1
    - ISO2
    - ISOLS
    - DBED
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - MDB
    - STAT
    - PERM
    - LIC
    - MANUAL.SML
    - PRINTER.SML
  - WHITE
    - ISO3
    - SCT3
    - FMS
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - SET
    - MDB
    - STAT
    - MINED
    - PERM
    - LIC
    - MANUAL.SML
    - PRINTER.SML
  - GENE
    - HSC
    - TUM
    - TLM
    - DCLM
    - ACHS
    - ACLM
    - SCHS
    - SCLM
    - DRILLH
    - OTC
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - STAT
    - PERM
    - LIC
    - SURF
    - UNCERT
    - MANUAL
    - PRINTE

T5355
Township — W. of the 5th meridian
Range

Figure 2. Data structure.

DATA STRUCTURE LEVELS 3 AND 4
C:\WABAMUN

- TWPS
  - T5345
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - SET
    - MDB
    - STAT
    - WISO3
    - WFMS
    - WSCT3
    - MINED
    - PERM
    - LIC
    - UNDER
    - UNCERT
    - SURF
    - MANUAL.SML
    - PRINTER.SML
  - T5255
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - STAT
    - HISO1
    - HISO2
    - HNGEOL
    - HNSC1
    - MINED
    - PERM
    - LIC
    - SURF
    - MANUAL.SML
    - PRINTER.SML
  - T5245
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - SET
    - STAT
    - HISO1
    - HISO2
    - HNGEOL
    - HNSC1
    - HSLS
    - HSDBED
    - MINED
    - PERM
    - LIC
    - UNDER
    - UNCERT
    - SURF
    - MANUAL.SML
    - PRINTER.SML
  - T5155
    - BND
    - ATS
    - RIV
    - HWY
    - STAT
    - MANUAL.SML
    - PRINTER.SML
  - T5145
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - STAT
    - HISO1
    - HISO2
    - HSLS
    - HSDBED
    - PERM
    - MANUAL.SML
    - PRINTER.SML
  - T5045
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - MDB
    - STAT
    - HISO1
    - HISO2
    - HSLS
    - HSDBED
    - PERM
    - MANUAL.SML
    - PRINTER.SML
  - T5035
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - MDB
    - STAT
    - GHSC
    - GDRILLH
    - GTUM
    - GSCLM
    - GDCLM
    - GTLM
    - GACHS
    - GACLM
    - GSCHS
    - GOTC
    - LIC
    - PERM
    - UNCERT
    - SURF
    - MANUAL.SML
    - PRINTER.SML
- SAREA
  - BND
  - ATS
  - RIV
  - LAK
  - HWY
  - SET
  - MDB
  - STAT
  - LIC
  - PERM
  - MINED
  - UNDER
  - UNCERT
  - SURF
  - OILBUF
  - PRINTER.SML
  - MANUAL.SML
- MINES
  - HIGHVA
    - ISO1
    - ISO2
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - SET
    - MDB
    - STAT
    - HVPNT
    - MINED
    - PERM
    - LIC
    - UNDER
    - SURF
    - UNCERT
    - SEAM1.SML
    - SEAM2.SML
    - SEAM3.SML
    - SEAM4.SML
    - SEAM5.SML
    - SEAM6.SML
    - MANUAL.SML
    - HV2.SML
    - OVB
    - SMPCD
    - PRINTER.SML
  - HIGHVN
    - ISO1
    - ISO2
    - GEOL
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - SET
    - STAT
    - SC1
    - MINED
    - PERM
    - LIC
    - UNDER
    - SURF
    - UNCERT
    - MANUAL.SML
    - PRINTER.SML
  - HIGHVS
    - ISO1
    - ISO2
    - ISOLS
    - DBED
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - MDB
    - STAT
    - PERM
    - LIC
    - MANUAL.SML
    - PRINTER.SML
  - WHITE
    - ISO3
    - SCT3
    - FMS
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - SET
    - MDB
    - STAT
    - MINED
    - PERM
    - LIC
    - MANUAL.SML
    - PRINTER.SML
  - GENE
    - HSC
    - TUM
    - TLM
    - DCLM
    - ACHS
    - ACLM
    - SCHS
    - SCLM
    - DRILLH
    - OTC
    - BND
    - ATS
    - RIV
    - LAK
    - HWY
    - STAT
    - PERM
    - LIC
    - SURF
    - UNCERT
    - MANUAL.SML
    - PRINTER.SML

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Township / Range / W. of the 5th meridian

. Data structure.

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